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PREFACE

This book provides a convenient reference of significant technical data relative to Mariner V. It compiles a wide variety of factual information that is scattered throughout a large number of documents.

The information presented pertains primarily to the Mariner V spacecraft itself and does not include the Launch Vehicle System, the ground support equipment, the Deep Space Network, or other areas which constitute the total Mariner Venus 67 Project.

The primary Mariner V mission began on 14 June 1967 and is considered to have ended on 1 December 1967. This handbook thus becomes a log or history of the spacecraft performance from launch to end of mission; however, in the tables and figures, some orbital and performance parameters have been projected through 1971, inasmuch as Mariner V spacecraft activity will continue.

ABBREVIATIONS

ADC/PNG	analog-to-digital converter/pseudonoise generator
AFETR	Air Force Eastern Test Range
AGC	automatic gain control
APAC	antenna pointing angle change
A/PW	analog-to-pulse width
CC&S	central computer and sequencer
DAS	data automation subsystem
DC	direct command
DFR	dual frequency receiver
DN	data number
DSCC	Deep Space Communication Complex
ESF	Explosive-Safe Facility
EU	engineering units
FA	flight acceptance
ID	identification data
LO	local oscillator
PAS	pyrotechnic arming switch
PIPS	post-injection propulsion system
PS&L	power switch and logic
PSO	planet sensor output
QC	quantitative command
SAF	Spacecraft Assembly Facility
SFOF	Space Flight Operations Facility
SIT	separation initiated timer
SPAC	spacecraft performance analysis and command
SPE	static phase error
TA	type approval
TCR	temperature control reference
TLM	telemetry
TPST	terminal peak saw tooth
TRD	trapped radiation detector
TWT	traveling wave tube
VCO	voltage-controlled oscillator

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ALBEDO (see Venus)

ALTITUDE

above Venus at closest approach — 4,094 km / 2,544 mi

above Venus during encounter (see Fig. 53)

above earth and Venus during mission (see Table 4 and Figs. 47–48)

above Venus at closest approach prior to midcourse maneuver — 69,675 km / 43,290 mi

ANTENNA (see Dual Frequency Receiver Antennas, High-Gain Antenna, Low-Gain Antenna)

ATTITUDE CONTROL (see also Canopus Sensor, Earth Sensor, Gyro Control Subsystem, Planet Sensor, Sun Sensors, Terminator Sensor)

CCW roll valve operation inhibit time — 30–35 s

derived rate time constants

charge

pitch and yaw — 15.5 s

roll — 9 s

discharge

pitch and yaw — 119 s

roll — 18 s

dynamic operation

minimum valve on time — 20 ms

minimum rate increment (2-valve operation)

pitch and yaw — 19 μrad/s

roll — 14 μrad/s

gas weight flow (per valve operation)

pitch and yaw — 1.4×10^{-6} lb

roll — 1.8×10^{-6} lb

electrical components, number of (see also Table 8) — 1261

electronics, location of — Bay VII

flight nozzle thrust levels (at 15 psi)

pitch and yaw — 2.25×10^{-3} lb

roll — 3.86×10^{-3} lb

gas

pressure vessel, diameter — 9 in.

pressure vessel designed nitrogen capacity (2 each) — 2.60 lb

pressurization in vessels — 2500 ±300 psi at 70°F

weight at launch — 5.2 lb

weight history (see Fig. 57)

ATTITUDE CONTROL (Cont'd)

gas jets	
number of	12
location of (see Fig. 4)	
gas valve	
firing power per valve	2.14 W
response time to open	8 ms
response time to close	3.5 ms
valve inlet pressure	15 ±1.2 psi
gyro operation time after Canopus sensor acquires an object	205 s (typical)
pitch and yaw	
position deadband	±9.0 mrad
rate deadband	±1.1 mrad/s
reference designations of subassemblies (see Table 7)	
roll	
position deadband	±4.5 mrad
rate deadband	±0.3 mrad/s
roll rate	
magnetometer calibration	3.5 mrad/s
Canopus search	2.0 mrad/s
steady-state operation	
acceleration constants (2-valve operation)	
pitch and yaw	0.48 mrad/s^2
roll	0.43 mrad/s^2
torque constants (2-valve operation)	
pitch and yaw	36×10^{-3} ft-lb
roll	56×10^{-3} ft-lb
gas weight flow rate (per valve)	
pitch and yaw	3.21×10^{-5} lb/s
roll	5.54×10^{-5} lb/s
thrust levels (see flight nozzle, above)	
weight, subsystem (see also Table 9)	56.98 lb
accelerometer	0.07 lb
gas systems	26.68 lb
gyro control and electronics	18.99 lb
jet vane actuator assembly	3.26 lb
sensors	7.98 lb

BATTERY (see Power Subsystem)

BAYS, SUBSYSTEM LOCATIONS IN

attitude control and central computer and sequencer	Bay VII

BAYS, SUBSYSTEM LOCATIONS IN (Cont'd)

data encoder and command subsystem	Bay IV
power and pyrotechnic control	Bay I
power regulator and battery	Bay VIII
propulsion	Bay II
RF communications (transmitter)	Bay VI
RF communications (receiver) and tape recorder	Bay V
scientific equipment and data automation subsystem	Bay III

BIT RATE

at launch	33-1/3 bps
capability	33-1/3 and 8-1/3 bps
changeover to 8-1/3 bps (see MT-6 and Table 25)	

BOOSTER REGULATORS (see Power Subsystem)

CABLING SUBSYSTEM

engineering information (see Table 13)	
quantity	
assembled cables	30
connector pins	7800
electrical connectors	290
harnesses	30
wires	3100
wire shields	227
wire splices	267
reference designation of subassemblies (see Table 7)	
type of conductor	
power leads	#22 AWG silver-plated copper
signal leads	#22 AWG silver-plated copper alloy
type of insulation	tape-wrapped TFE Teflon, nominal 10-mil thickness, treated for bondability
weight of subsystem, excluding support hardware (see also Table 9)	43.63 lb
weight of support hardware	3.57 lb

CANOPUS SENSOR

acquisition levels (star in view)	
acquisition gate on	>0.3 × Canopus brightness
acquisition gate off	<0.25 × Canopus brightness
cone angle of Canopus at launch	76–77 deg
cone angle change increment	5.125 deg
cone angle limits	74.5–111.2 deg
cone angle settings (see also Fig. 7)	
preset	80 deg
MT-1	85.1 deg
MT-2	90.3 deg
MT-3	95.4 deg
MT-4	100.5 deg
optional	105.7 deg
electron aperture dimensions	0.160 × 0.012 in.
field of view	
cone direction	11 deg
clock direction	4 deg
excursion of cone field of view	25 deg
focal length	0.8 in.
light level required for 1.0 × Canopus	0.5×10^{-6} ft-cd
linear range	±0.85 deg
null accuracy	0.125 deg
operating range	35–100°F
power required	1.45 W
reference designation of unit	7CS8
roll search rate of spacecraft for star acquisition	2.0 mrad/s
scale factor	8 V/deg ±20%
sensitivity threshold	0.02 × Canopus brightness
speed	
effective	f/1.0
geometric	f/0.6
sun shutter	
turn-on level	1000 ±200 ft-cd
turn-off level	600 ft-cd
weight (see also Table 7)	6.28 lb

CANOPUS–SPACECRAFT–SUN ANGLE

injection	14 Jun	76.9 deg
midcourse maneuver	19 Jun	76.7 deg
changeover to traveling wave tube amplifier	27 Jun	76.6 deg

CANOPUS–SPACECRAFT–SUN ANGLE (Cont'd)

MT-6 changeover to 8-1/3 bps	24 Jul	78.0 deg
MT-1 Canopus cone angle update	24 Aug	83.2 deg
MT-2 Canopus cone angle update	10 Sep	87.8 deg
MT-3 Canopus cone angle update	26 Sep	93.3 deg
MT-5 changeover to high-gain antenna	1 Oct	95.0 deg
MT-4 Canopus cone angle update	10 Oct	98.0 deg
DC-V15 Canopus gate override	10 Oct	98.0 deg
closest approach	19 Oct	100.6 deg
end of mission	1 Dec	102.4 deg
from end of mission through 1971 (see Fig. 45)		

CAVITY AMPLIFIER (see Radio)

CELESTIAL LATITUDE, MARINER V (see also Fig. 50)

injection	14 Jun	0.00 deg
midcourse maneuver	19 Jun	−0.26 deg
changeover to traveling wave tube amplifier	27 Jun	−0.55 deg
MT-6 changeover to 8-1/3 bps	24 Jul	−1.63 deg
MT-1 Canopus cone angle update	24 Aug	−2.52 deg
MT-2 Canopus cone angle update	10 Sep	−2.65 deg
MT-3 Canopus cone angle update	26 Sep	−2.37 deg
MT-5 changeover to high-gain antenna	1 Oct	−2.19 deg
MT-4 Canopus cone angle update	10 Oct	−1.73 deg
closest approach	19 Oct	−1.13 deg
end of mission	1 Dec	0.35 deg
from end of mission through 1971 (see Table 5)		

CELESTIAL LONGITUDE, EARTH

injection	14 Jun	262.5 deg
midcourse maneuver	19 Jun	268.0 deg
changeover to traveling wave tube amplifier	27 Jun	274.7 deg
MT-6 changeover to 8-1/3 bps	24 Jul	300.9 deg
MT-1 Canopus cone angle update	24 Aug	330.6 deg
MT-2 Canopus cone angle update	10 Sep	346.6 deg
MT-3 Canopus cone angle update	26 Sep	2.7 deg
MT-5 changeover to high-gain antenna	1 Oct	7.6 deg
MT-4 Canopus cone angle update	10 Oct	16.5 deg
closest approach	19 Oct	25.7 deg
end of mission	1 Dec	68.1 deg

CELESTIAL LONGITUDE, MARINER V (see also Fig. 51)

injection	14 Jun	262.5 deg

CELESTIAL LONGITUDE, MARINER V (Cont'd)

midcourse maneuver	19 Jun	267.5 deg
changeover to traveling wave tube amplifier	27 Jun	273.8 deg
MT-6 changeover to 8-1/3 bps	24 Jul	299.5 deg
MT-1 Canopus cone angle update	24 Aug	333.3 deg
MT-2 Canopus cone angle update	10 Sep	354.5 deg
MT-3 Canopus cone angle update	26 Sep	18.5 deg
MT-5 changeover to high-gain antenna	1 Oct	26.4 deg
MT-4 Canopus cone angle update	10 Oct	41.1 deg
closest approach	19 Oct	56.9 deg
end of mission	1 Dec	129.6 deg
from end of mission through 1971 (see Table 5)		

CELESTIAL LONGITUDE, VENUS

launch	14 Jun	214.2 deg
midcourse maneuver	19 Jun	223.4 deg
changeover to traveling wave tube amplifier	27 Jun	234.6 deg
MT-6 changeover to 8-1/3 bps	24 Jul	278.3 deg
MT-1 Canopus cone angle update	24 Aug	327.3 deg
MT-2 Canopus cone angle update	10 Sep	353.5 deg
MT-3 Canopus cone angle update	26 Sep	19.7 deg
MT-5 changeover to high-gain antenna	1 Oct	27.7 deg
MT-4 Canopus cone angle update	10 Oct	42.1 deg
closest approach	19 Oct	56.9 deg
end of mission	1 Dec	125.2 deg

CENTER OF GRAVITY (see Spacecraft)

CENTRAL COMPUTER AND SEQUENCER

basic timing frequency output	38.4 kHz
central clock oscillator	
frequency	307.2 kHz
frequency stability	±0.01% at −10 to +75°C
command descriptions (see Table 24)	
commands	
launch phase	L-1–L-3
midcourse maneuver phase	M-1–M-7
cruise phase	MT-1–MT-6
encounter phase	MT-7–MT-9
midcourse maneuver turn timing	TM2-B
cyclic, every 66-2/3 h	CY-1
commands, number of	21

CENTRAL COMPUTER AND SEQUENCER (Cont'd)

electrical components, number of (see also Table 8)	2570
frequency outputs	
to power	38.4 kHz
to radio	1 pulse/66-2/3 h
location on spacecraft	Bay VII
power required (2.4-kHz square wave)	
during boost	10.5 W ±10%
during cruise	4.5 W ±10%
reference designations of subassemblies (see Table 7)	
voltages required for operation	
input (2.4-kHz square wave)	50 Vac ±20%
internal dc voltages	65 Vdc ±20%
	28 Vdc ±20%
	16 Vdc ±20%
weight (see also Table 9)	12.23 lb

CLOCK (see Central Computer and Sequencer, Data Automation Subsystem)

CLOCK ANGLE

explanation of (see Fig. 5)

COMMAND SUBSYSTEM

command bit rate	1 bps
command format (see Fig. 19)	
electrical components, number of (see also Table 8)	2615
location on spacecraft	Bay IV
number of bits per command word	26
number of direct commands (DC)	29
number of significant bits per DC command	11
address parity bits	2
command bits	9
number of quantitative commands (QC) (see also Table 24)	1 (3)
number of significant bits per QC command	26
power required, nominal	3.6 W
reference designations of subassemblies (see Table 7)	
subsystems using commands	
attitude control	8
central computer and sequencer (includes QC commands)	2
data automation subsystem	2

COMMAND SUBSYSTEM (Cont'd)

subsystems using commands (cont'd)
data encoder 5
power 4
pyrotechnic 6
radio 6
tape recorder 1
weight (see also Table 9) 10.37 lb

COMMANDS

command descriptions (see Tables 24 and 25)

COMMUNICATION TIMES, ONE WAY

midcourse maneuver	19 Jun	5.27 s
changeover to traveling wave tube amplifier	27 Jun	11.27 s
MT-6 changeover to 8-1/3 bps	24 Jul	35.4 s
MT-1 Canopus cone angle update	24 Aug	1 min, 18 s
MT-2 Canopus cone angle update	10 Sep	1 min, 56 s
MT-3 Canopus cone angle update	26 Sep	2 min, 49 s
MT-5 changeover to high-gain antenna	1 Oct	3 min, 8 s
MT-4 Canopus cone angle update	10 Oct	3 min, 45 s
closest approach	19 Oct	4 min, 26 s
end of mission	1 Dec	7 min, 20 s

COMPUTER (see Central Computer and Sequencer)

CONE ANGLE

explanation of (see Fig. 5)
update mechanics (see Canopus Sensor and Fig. 7)

DATA (see Telemetry)

DATA AUTOMATION SUBSYSTEM

electrical components, number of (includes components in analog/pulse width converters; see also Table 8) 1173
location on spacecraft Bay III
power required 11.0 W
reference designations of subassemblies (see Table 7)
telemetry format (see Figs. 29, 31, 32 and 33)
weight (see also Table 9) 14.60 lb

DATA ENCODER SUBSYSTEM

number of bits in binary engineering words 7

DATA ENCODER SUBSYSTEM (Cont'd)

number of commutator channels		100
electrical components, number of (see also Table 8)		7585
location on spacecraft		Bay IV
power required		8.75 W, av 9.04 W, peak
reference designations of subassemblies (see Table 7)		
telemetry commutation (see Fig. 23)		
telemetry format (see Telemetry)		
time between samples (see Table 22)		
weight (see also Table 9)		23.40 lb

DATA MODES (see Telemetry)

DIPOLE MOMENT OF EARTH 8.06×10^{25} G/cm^3

DISTANCE OF MARINER V FROM EARTH (see also Fig. 47)

weekly intervals during flight (see Table 4)		
midcourse maneuver	19 Jun	1,581,615 km 982,770 mi
changeover to traveling wave tube amplifier	27 Jun	3,380,808 km 2,100,737 mi
MT-6 changeover to 8-1/3 bps	24 Jul	10,622,390 km 6,600,447 mi
MT-1 Canopus cone angle update	24 Aug	23,341,070 km 14,503,469 mi
MT-2 Canopus cone angle update	10 Sep	34,915,052 km 21,695,207 mi
MT-3 Canopus cone angle update	26 Sep	50,836,609 km 31,588,404 mi
MT-5 changeover to high-gain antenna	1 Oct	56,494,636 km 35,104,139 mi
MT-4 Canopus cone angle update	10 Oct	67,503,928 km 41,944,996 mi
closest approach	19 Oct	79,764,757 km 49,563,522 mi
end of mission	1 Dec	131,902,210 km 81,960,233 mi
from end of mission through Dec 1971 (see Table 5)		
at closest approach, 27 Oct 1968		38,995,007 km 24,230,374 mi

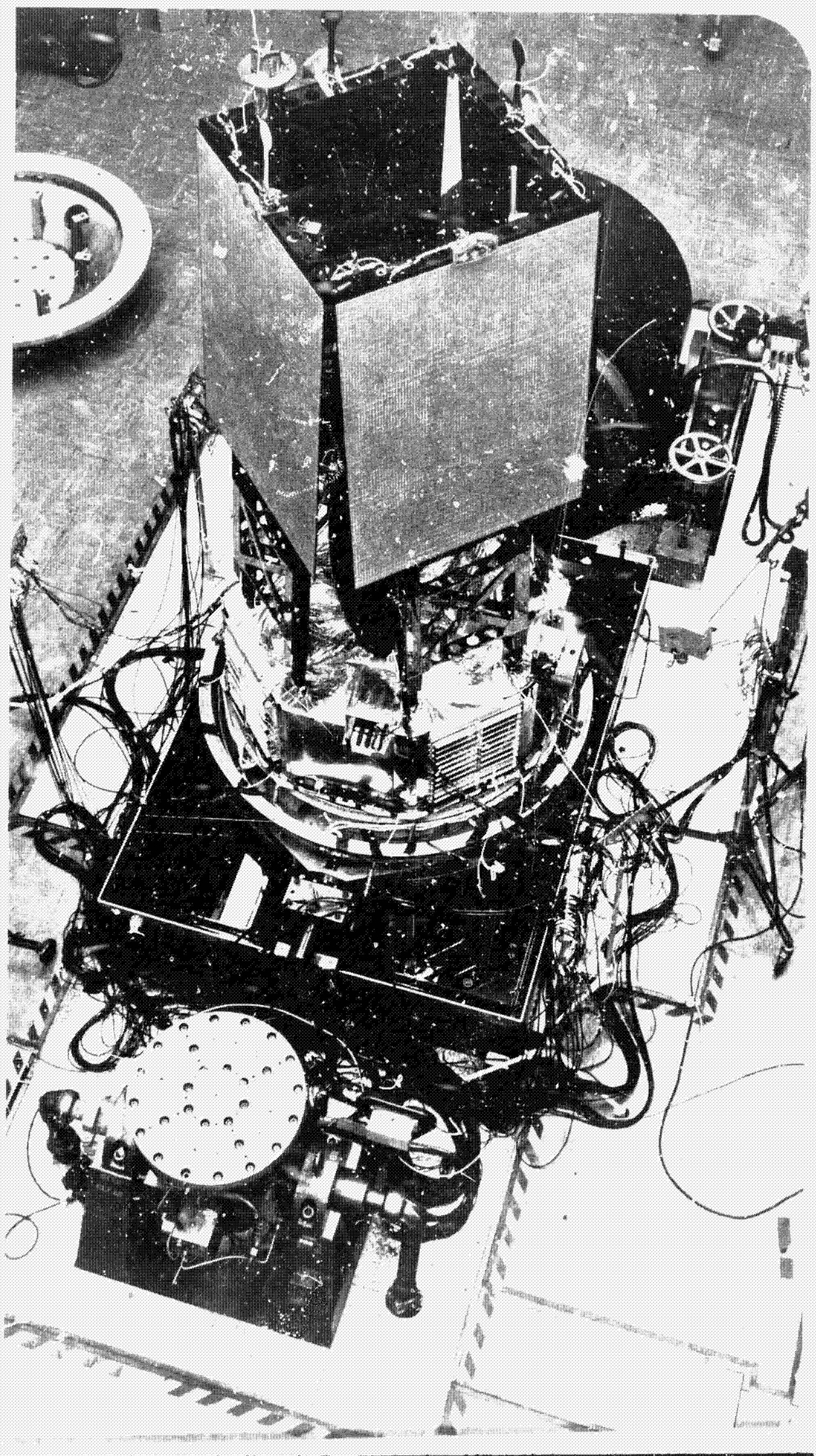
DISTANCE OF MARINER V FROM CENTER OF VENUS (see also Fig. 48)

launch	14 Jun	113,721,860 km 70,663,486 mi
midcourse maneuver	19 Jun	105,427,870 km 65,509,840 mi
changeover to traveling wave tube amplifier	27 Jun	95,255,438 km 59,188,984 mi
MT-6 changeover to 8-1/3 bps	24 Jul	57,234,319 km 35,563,756 mi
MT-1 Canopus cone angle update	24 Aug	24,201,792 km 15,038,296 mi
MT-2 Canopus cone angle update	10 Sep	13,212,249 km 8,209,711 mi
MT-3 Canopus cone angle update	26 Sep	6,522,823 km 4,053,094 mi
MT-5 changeover to high-gain antenna	1 Oct	5,027,332 km 3,123,839 mi
MT-4 Canopus cone angle update	10 Oct	2,564,426 km 1,593,460 mi
closest approach	19 Oct	10,150 km 6,307 mi
end of mission	1 Dec	15,669,615 km 9,736,648 mi

DISTANCE OF MARINER V FROM SUN (see also Fig. 49)

weekly intervals during flight (see Table 4)		
launch	14 Jun	151,945,190 km 94,414,363 mi
midcourse maneuver	19 Jun	151,283,640 km 94,003,294 mi
changeover to traveling wave tube amplifier	27 Jun	150,219,090 km 93,341,817 mi
MT-6 changeover to 8-1/3 bps	24 Jul	142,858,570 km 88,768,201 mi
MT-1 Canopus cone angle update	24 Aug	129,662,180 km 80,568,343 mi
MT-2 Canopus cone angle update	10 Sep	121,731,330 km 75,640,340 mi

The Mariner V structural test model setup for the lateral axis vibration test at JPL



DISTANCE OF MARINER V FROM SUN (Cont'd)

MT-3 Canopus cone angle update	26 Sep	114,470,020 km 71,128,374 mi
MT-5 changeover to high-gain antenna	1 Oct	112,609,670 km 69,972,406 mi
MT-4 Canopus cone angle update	10 Oct	109,869,090 km 68,269,484 mi
closest approach	19 Oct	108,038,200 km 67,113,186 mi
end of mission	1 Dec	94,415,840 km 58,667,282 mi
from end of mission through 1971 (see Table 5)		

DISTANCE TRAVELED ALONG HELIOCENTRIC ARC BY MARINER V (see also Fig. 46)

midcourse maneuver	19 Jun	13,265,932 km 8,243,052 mi
changeover to traveling wave tube amplifier	27 Jun	31,052,281 km 19,294,993 mi
MT-6 changeover to 8-1/3 bps	24 Jul	96,431,352 km 59,919,664 mi
MT-1 Canopus cone angle update	24 Aug	177,752,162 km 110,472,630 mi
MT-2 Canopus cone angle update	10 Sep	226,342,582 km 140,642,760 mi
MT-3 Canopus cone angle update	26 Sep	274,839,713 km 170,777,480 mi
MT-5 changeover to high-gain antenna	1 Oct	290,516,461 km 180,518,560 mi
MT-4 Canopus cone angle update	[illegible]	319,265,219 km 198,382,210 mi
closest approach	19 Oct	349,248,682 km 217,013,070 mi
end of mission	1 Dec	479,293,269 km 297,819,030 mi
in one complete revolution around sun, 1 Jan 1968		685,431,149 km 425,907,170 mi

DUAL FREQUENCY RECEIVER

data rate (cruise)	1.51 bps (high) 0.38 bps (low)
data rate (encounter)	70 bps
electrical components, number of (see also Table 8)	1274

DUAL FREQUENCY RECEIVER (Cont'd)

frequency	423.3 MHz 49.8 MHz
intermediate	24.3 MHz
input impedance	50 ohms
power input	2.4 kHz, 50 V rms, 1 ϕ square wave
2.4-kHz power consumption (nominal)	2.0 W
location on spacecraft	Bay III
noise temperature, antenna terminals	
423.3 MHz	1500°K
49.8 MHz	8300°K
temperature ranges	
desired operating range	+10 to +30°C
operating limits, worst case	−10 to +75°C
nonoperating limits, stored, power off	−45 to +85°C
threshold sensitivity	
423.3 MHz	−136.2 dBm
49.8 MHz	−129.2 dBm
weight (see also Table 9)	6.83 lb
cables	0.65 lb
clamps and holders	0.15 lb
filters	0.93 lb
receiver	5.10 lb

DUAL FREQUENCY RECEIVER ANTENNAS

impedance (nominal)	50 ohms
input frequencies	
VHF	49.8 MHz
UHF	423.3 MHz
maximum gain (relative to linear isotropic)	
VHF, at 49.8 MHz (referenced to base of coaxial tee)	0.0 ±2.5 dB
UHF, at 423.3 MHz (referenced to antenna mast connector)	+6.0 ±1.5 dB
line loss (see Fig. 39)	
VHF (from base of tee to receiver)	1.0 dB
UHF (from antenna mast connector to receiver)	0.9 dB
mode	receive only
polarization	
VHF	linear
UHF	linear

DUAL FREQUENCY RECEIVER ANTENNAS (Cont'd)

radiation pattern, VHF	
beam shape (in plane, normal to RF boresight)	approximately elliptical
beamwidth at −3 dB, major axis of pattern	140 deg
beamwidth at −3 dB, minor axis of pattern	55 deg
RF boresight relative to direction of earth at encounter	within 30 deg
radiation pattern, UHF	
beam shape	approximately circular
beamwidth at −3 dB	55 deg
RF boresight cone angle at encounter	15 deg
type (see also Fig. 39)	
VHF	integral with spacecraft solar panel structure employing a shunt feed of two panels
UHF	stub radiator (approximately $\lambda/4$ long) with 2 reflector elements over 4 ground plane radials mounted on end of solar panel
voltage standing wave ratio	
VHF, at 49.8 MHz	less than 1.5 to 1
UHF, at 423.3 MHz	less than 1.5 to 1
weight, total (see also Table 9)	0.94 lb
VHF (feed units)	0.21 lb ea
UHF	0.52 lb

EARTH SENSOR

calibration (see Fig. 9)	
field of view (see also Fig. 8)	
cone direction	50 deg
clock direction	3 deg
look angle, cone direction	132 deg
look angle, clock direction	270 deg
reference designation of instrument	7ED6
sensitivity threshold	0.001 ft-cd

EARTH–SPACECRAFT–SUN ANGLE

midcourse maneuver	19 Jun	117.1 deg
changeover to traveling wave tube amplifier	27 Jun	122.7 deg
MT-6 changeover to 8-1/3 bps	24 Jul	147.9 deg
MT-1 Canopus cone angle update	24 Aug	155.7 deg
MT-2 Canopus cone angle update	10 Sep	141.6 deg
MT-3 Canopus cone angle update	26 Sep	125.8 deg
MT-5 changeover to high-gain antenna	1 Oct	121.0 deg
MT-4 Canopus cone angle update	10 Oct	112.5 deg
closest approach	19 Oct	104.0 deg
end of mission	1 Dec	79.5 deg

ENCOUNTER

date	19 Oct 1967
day of flight	127
time, GMT	17:34:56
communication time (one way)	4 min, 26 s
earth–spacecraft–sun angle	104.0 deg
Canopus–spacecraft–sun angle	100.6 deg
spacecraft celestial longitude	56.9 deg
spacecraft celestial latitude	−1.13 deg
earth celestial longitude	25.7 deg
Venus celestial longitude	56.9 deg
spacecraft distance from earth	79,764,368 km 49,563,280 mi
spacecraft distance from sun	108,008,250 km 67,113,211 mi
distance traveled along heliocentric arc	349,247,530 km 217,011,940 mi
spacecraft distance from center of Venus	10,150.0 km 6,306.9 mi
spacecraft altitude above Venus surface	4,094 km 2,544 mi
spacecraft velocity relative to earth	56,706 mph
spacecraft velocity relative to Venus	19,157 mph
spacecraft velocity relative to sun	85,003 mph

END OF MISSION

date	1 Dec 1967
day of flight	170
communication time (one way)	7 min, 20 s
earth–spacecraft–sun angle	79.5 deg
Canopus–spacecraft–sun angle	102.4 deg
spacecraft celestial longitude	128.6 deg

END OF MISSION (Cont'd)

spacecraft celestial latitude	0.35 deg
earth celestial longitude	68.1 deg
Venus celestial longitude	125.2 deg
spacecraft distance from earth	131,902,210 km 81,960,233 mi
spacecraft distance from sun	94,415,840 km 58,667,282 mi
spacecraft distance from Venus	15,669,615 km 9,736,648 mi
distance traveled along heliocentric arc	479,293,269 km 297,819,030 mi
spacecraft velocity relative to earth	86,224 mph
spacecraft velocity relative to Venus	16,655 mph
spacecraft velocity relative to sun	85,513 mph
number of commands sent	94

ENVIRONMENTAL TESTS (see Tables 14–18)

EXCITERS (see Radio)

EXPERIMENTS (see Table 6)

FIELDS OF VIEW

Canopus sensor	
cone direction	11 deg
clock direction	4 deg
earth sensor	
cone direction	50 deg
clock direction	3 deg
planet sensor (aligned +41°4′ clock)	4.55 × 1.55 deg
plasma probe	30-deg half-angle cone
sun gate	2.2-deg half-angle cone
sun sensors	
primary sensors	±2 deg, each axis
secondary sensors	4π sr
terminator sensor	
cone direction	2.5 deg
clock direction	1.5 deg
trapped radiation detectors	180 deg

FLIGHT EVENT TIMES, 1967, GMT

launch of Mariner V		
liftoff	14 Jun	06:01:00
Atlas booster engine cutoff		06:03:09
Atlas booster separation		06:03:12

FLIGHT EVENT TIMES, 1967, GMT (Cont'd)

launch of Mariner V (cont'd)

Atlas sustainer engine cutoff	14 Jun	06:05:57
Atlas vernier engine cutoff		06:06:18
shroud ejection		06:06:20
Atlas/Agena separation		06:06:22
Agena first burn ignition		06:07:22
Agena first burn cutoff		06:09:46
in parking orbit		06:09:46
Agena second burn ignition		06:23:01
Agena second burn cutoff		06:24:36
Agena/spacecraft separation		06:27:17
solar panels deployed		06:30:19
Agena posigrade maneuver		06:32:17
sun acquisition start		06:33:50
sun acquisition complete		06:43:25

Canopus acquisition

DC-V21 transmitted	15 Jun	00:30:00
DC-V21 transmitted		00:34:00
Canopus acquired		01:09:13

cyclics, CC&S CY-1 (occur every 66-2/3 h)

CC&S CY-1 No. 1		21:58:07

midcourse maneuver

QC-V1-1 transmitted	19 Jun	20:18:00
QC-V1-2 transmitted		20:23:00
QC-V1-3 transmitted		20:28:00
DC-V29 transmitted		20:38:00
DC-V14 transmitted		20:48:00
DC-V27 transmitted		21:23:57
end of motor burn		23:08:28
sun acquisition start		23:14:11
sun acquisition complete		23:21:24
Canopus acquired		23:32:19

CCW 360-deg roll searches (UV data)

DC-V21 transmitted		23:33:15
Canopus acquired	20 Jun	00:23:58
DC-V21 transmitted		00:25:00
Canopus acquired		01:16:54
DC-V21 transmitted		01:17:50
Canopus acquired		02:06:15

stabilization to cruise mode

minimum QC-V1-1 transmitted		02:19:00
minimum QC-V1-2 transmitted		02:24:00
minimum QC-V1-3 transmitted		02:29:00

FLIGHT EVENT TIMES, 1967, GMT (Cont'd)

ranging (lunar) from midcourse to TWT changeover		
DC-V9 (switch ranging receiver on) transmitted	20 Jun	02:39:00
CC&S CY-1 No. 3 (switch ranging receiver off)	21 Jun	11:18:14
DC-V9 (switch ranging receiver on) transmitted		19:25:00
CC&S CY-1 No. 4 (switch ranging receiver off)	24 Jun	05:58:27
DC-V9 (switch ranging receiver on) transmitted	25 Jun	03:08:00
DC-V9 (switch ranging receiver off) transmitted	26 Jun	23:45:00
changeover to TWT power amplifier		
DC-V7 transmitted	27 Jun	00:28:00
switch battery charger off		
DC-V28 transmitted		00:58:00
ranging (lunar) to changeover to ranging (planetary)		
DC-V9 (switch ranging receiver on) transmitted		01:18:00
CC&S CY-1 No. 6 (switch ranging receiver off)	28 Jun	19.18:35
DC-V9 (switch ranging receiver on) transmitted	30 Jun	19:45:00
CC&S CY-1 No. 7 (switch ranging receiver off)	2 Jul	13:58:45
DC-V9 (switch ranging receiver on) transmitted	6 Jul	00:30:00
CC&S CY-1 No. 9 (switch ranging receiver off)	8 Jul	03:18:53
ranging (pianetary) to MT-6 event		
DC-V9 (switch ranging receiver on) transmitted		19:30:00
CC&S CY-1 No. 10 (switch ranging receiver off)	10 Jul	21:59:09
DC-V9 (switch ranging receiver on) transmitted	22 Jul	01:35:00
CC&S CY-1 No. 15 (switch ranging receiver off)	24 Jul	19:19:21

FLIGHT EVENT TIMES, 1967, GMT (Cont'd)

MT-6, switch bit rate to 8-1/3 bps		
CC&S MT-6	24 Jul	19:19:21
ranging (planetary) to MT-1 event		
DC-V9 (switch ranging receiver on) transmitted	27 Jul	16:40:00
CC&S CY-1 No. 17 (switch ranging receiver off)	29 Jul	08:40:20
MT-1, Canopus cone angle update to 85.125 deg	24 Aug	08:41:33
MT-2, Canopus cone angle update to 90.25 deg	10 Sep	00:41:52
MT-3, Canopus cone angle update to 95.375 deg	26 Sep	16:42:43
MT-5, changeover to high-gain antenna	1 Oct	16:43:33.8
ranging (planetary) to MT-4		
DC-V9 (switch ranging receiver on) transmitted	5 Oct	23:55:00
CC&S CY-1 No. 42 (switch ranging receiver off)	7 Oct	19:23:39
DC-V9 (switch ranging receiver on) transmitted	9 Oct	22:00:00
DC-V9 (switch ranging receiver off) transmitted	10 Oct	13:50:00
MT-4, Canopus cone angle update to 100.5 deg		14:04:14.4
Canopus gate inhibit override		
DC-V15 transmitted		14:25:00
ranging (planetary) to encounter		
DC-V9 (switch ranging receiver on) transmitted		14:30:00
CC&S CY-1 No. 44 (switch ranging receiver off)	13 Oct	08:44:33.9
DC-V9 (switch ranging receiver on) transmitted		12:42:00
CC&S CY-1 No. 45 (switch ranging receiver off)	16 Oct	03:24:53.8
DC-V9 (switch ranging receiver on) transmitted	17 Oct	16:10:00
CC&S CY-1 No. 46 (switch ranging receiver off)	18 Oct	22:05:13.9
encounter sequence		
DC-V25 transmitted	19 Oct	02:49:00

FLIGHT EVENT TIMES, 1967, GMT (Cont'd)

encounter sequence (cont'd)

DC-V25 observed on earth	19 Oct	02:58:25
terminator sensor status verified		03:11:39.3
nominal magnetometer calibration		04:11:00
MT-7 (backup to DC-V25)		04:45:05.8
DC-V9 (switch ranging receiver on) transmitted		08:50:00
DC-V9 observed on earth		08:59:38.8
DC-V24 transmitted		10:50:00
MT-8, DAS encounter sequence start		11:25:03.6
DC-V16 transmitted		15:01:43
DAS clock A enable		15:11:00
DC-V16 observed on earth		15:11:36
planet sensor output (PSO) science frame 98		16:33:57*
PSO terminated		16:37:59*
DC-V9 (switch ranging receiver off) transmitted		16:40:00
track 2 record start		16:46:46
DC-V9 observed on earth		16:49:17
plasma changes indicating the magnetopause		16:56:00
		17:01:00
		17:12:00
PSO in science frames 148–152		17:14:57*
PSO terminated, science frame 153		17:18:09*
closest approach (4094 km)		17:34:56
enter S-band occultation (closed-loop receiver)		17:38:09
enter DFR occultation (49.8 MHz)		17:38:10
enter DFR occultation (423.3 MHz)		17:39:00
enter S-band occultation (open-loop receiver)		17:42:05
terminator sensor output, science frame 185		17:46:49
exit S-band occultation		17:59:59
exit DFR occultation (423.3 MHz)		18:00:31
exit DFR occultation (49.8 MHz)		18:00:51
dual frequency receiver lockup		18:03:13
antenna pointing angle change (APAC) backup		18:19:10

*Times given are ± 25 s.

FLIGHT EVENT TIMES, 1967, GMT (Cont'd)

encounter sequence (cont'd)

end of track 2 data	19 Oct	18:34:18
tape recorder off (frame 251)		18:41:51
DC-V9 (switch ranging receiver on) transmitted		19:00:00
DC-V9 observed on earth		19:09:30
roll transient observed		20:40:12
roll transient observed	20 Oct	00:40:28

playback

MT-9, switch to data mode 4		07:25:23.4
switch to data mode 1		07:26:12
switch to data mode 4, begin track 1 test pattern		07:44:33
switch to data mode 1		08:00:36
roll transient observed		08:04:50
switch to data mode 4, beginning of prelaunch data		08:15:38
begin track 1 Venus encounter data		08:17:52
end of tape No. 1, switch to data mode 1	21 Oct	01:13:01
switch to data mode 4, all ones		01:14:28
switch to data mode 1		01:14:35
switch to data mode 4, begin track 2 test pattern		01:32:59
switch to data mode 1		01:49:03
switch to data mode 4, begin track 2 *Venus encounter data*		03:58:08
switch to data mode 1		18:18:30
DC-V9 (switch ranging receiver on) transmitted		18:45:00
DC-V9 observed on earth		18:54:44
end of tape No. 2, switch to data mode 4, begin second playback		19:18:17
switch to data mode 1		19:19:54
switch to data mode 4, begin track 1 *test pattern*		19:38:08
switch to data mode 1		19:54:14
switch to data mode 4, beginning of prelaunch data		20:09:32
begin track 1, Venus encounter data		20:11:45
end of tape No. 3, switch to data mode 1	22 Oct	13:06:52
switch to data mode 4, all ones		13:08:20
switch to data mode 1		13:08:28

FLIGHT EVENT TIMES, 1967, GMT (Cont'd)

playback (cont'd)		
switch to data mode 4, begin track 2 test pattern	22 Oct	13:26:03
switch to data mode 1		13:42:06
switch to data mode 4, begin track 2 of Venus encounter data		15:51:29
switch to data mode 1	23 Oct	06:11:50
end of tape No. 4, begin third playback		07:11:39
switch to data mode 4, begin track 1 test pattern		07:31:31
switch to data mode 1		07:47:31
DC-V2 transmitted (switch to data mode 2)		07:55:00
switch to data mode 4, beginning of prelaunch data		08:02:54
DC-V2 observed, switch to data mode 2, stop playback 13 s before start of track 1 Venus encounter data		08:04:54
DC-V28 transmitted		08:25:00
DC-V28 observed on earth		08:35:27
switch bit rates		
DC-V5 No. 1 transmitted, switch to 33-1/3 bps rate	25 Oct	16:30:00
DC-V5 No. 1 observed on earth		16:39:32
DC-V5 No. 2 transmitted, switch to 8-1/3 bps rate		20:35:00
DC-V5 No. 2 observed on earth		20:44:33
attitude control subsystem returned to normal optical control		
DC-V19 transmitted	26 Oct	20:55:00
DC-V19 observed on earth		21:05:56
turn off battery charger		
DC-V28 transmitted		21:12:30
DC-V28 observed on earth		21:23:51
switch ranging receiver on		
DC-V9 transmitted	4 Nov	16:35:00
DC-V9 observed on earth		16:45:46
switch ranging receiver off		
CCAS CY-1 No. 53	7 Nov	08:46:26
three-roll exercise for ultraviolet photometer		
DC-V26 transmitted		09:15:00

FLIGHT EVENT TIMES, 1967, GMT (Cont'd)

three-roll exercise for ultraviolet photometer (cont'd)

DC-V25 transmitted	7 Nov	09:20:00
DC-V26 observed on earth		09:26:47
DC-V25 observed on earth		09:31:51
DC-V16 transmitted		10:13:00
DC-V16 observed on earth		10:24:47
DC-V2 transmitted		10:30:00
DC-V2 observed on earth		10:42:09
DC-V21 No. 1 transmitted		12:16:10
DC-V12 No. 1 transmitted (spacecraft did not receive this command)		12:17:10
DC-V21 No. 1 (start of roll) observed on earth		12:27:54
DC-V21 No. 2 transmitted		13:12:46
Canopus acquired		13:13:00
DC-V12 No. 2 transmitted		13:20:00
DC-V21 No. 2 observed on earth		13:24:30
DC-V12 No. 3 transmitted		13:25:00
DC-V12 No. 2 observed on earth		13:32:00
DC-V12 No. 3 observed on earth		13:37:00
DC-V21 No. 3 transmitted		14:02:00
DC-V21 No. 4 transmitted		14:06:00
Canopus acquired		14:11:25
end of tape (record sequence)		14:33:30
DC-V10 transmitted		15:15:00
DC-V10 observed on earth		15:26:07

playback of ultraviolet photometer data

DC-V4 transmitted	8 Nov	21:00:00
DC-V4 observed on earth		21:11:59
switch to data mode 1		21:13:23
switch to data mode 4		21:31:44
switch to data mode 1		21:47:41
switch to data mode 4		22:03:08
end of tape, data mode 1	9 Nov	15:00:04
switch to data mode 4		15:19:15
switch to data mode 1		15:35:16
switch to data mode 4		17:45:54
DC-V2 transmitted		19:45:00
DC-V2 observed on earth		19:57:07
DC-V4 transmitted	10 Nov	05:00:00
DC-V4 observed on earth		05:12:25
switch to data mode 1		17:21:17
end of tape, data mode 4		18:19:08

FLIGHT EVENT TIMES, 1967. GMT (Cont'd)

playback of ultraviolet photometer data (cont'd)		
switch to data mode 1	10 Nov	18:20:40
switch to data mode 4		18:39:01
switch to data mode 1		18:55:03
DC-V2 transmitted		18:58:10
DC-V2 observed on earth		19:10:24
DC-V28 transmitted		19:15:00
DC-V28 observed on earth		19:27:46
DC-V28 transmitted		19:30:00
DC-V28 observed on earth		19:42:46
switch ranging receiver on		
DC-V9 transmitted		19:45:00
switch ranging receiver off		
CC&S CY-1 No. 55	12 Nov	22:06:39
exercise to point the ultraviolet photometer at the MT-6 point in space		
QC-V1-1 (minimum) transmitted	19 Nov	13:00:00
QC-V1-2 (minimum) transmitted		13:05:00
QC-V1-1 (17.18-deg pitch) observed on earth		13:14:17
QC-V1-2 (1800-s roll) observed on earth		13:18:28
DC-V14 transmitted		13:25:00
DC-V26 transmitted		13:30:00
DC-V25 transmitted		13.35:00
DC-V14 observed on earth		13:38:39
DC-V26 observed on earth		13:43:42
DC-V25 observed on earth		13:48:30
DC-V16 transmitted		13:50:12
DC-V16 observed on earth		14:03:56
DC-V2 transmitted		14:06:00
DC-V2 observed on earth		14:19:34
tape recorder on		14:21:13
DC-V29 transmitted		14:25:00
DC-V29 observed on earth		14:39:08
DC-V27 transmitted		14:53:15
DC-V2 transmitted		15:05:00

Project Office personnel at SFOF, awaiting news of Mariner V launch

FLIGHT EVENT TIMES, 1967, GMT (Cont'd)

exercise to point the ultraviolet photometer (cont'd)

DC-V27 observed on earth, data mode 1	19 Nov	15:06:49
DC-V2 observed on earth, data mode 2		15:18:30
DC-V12 transmitted		15:51:00
DC-V12 observed on earth		16:04:49
start tape in science frame 145		16:04:54
track 1 record		16:05:30
CCW pitch turn start		16:06:17
begin track 2 record		not in data
start roll turn (+313 deg)		not in data
start burn (inhibited)		not in data
stop burn		not in data
stop roll/start sun reacquisition		not in data
acquisition of Canopus		17:41:30
end of track 2 record		18:05:36
end of track 1 record		18:12:30
DC-V10 transmitted		18:15:00
DC-V10 observed on earth		18:28:49
DC-V13 transmitted		18:40:00
DC-V26 transmitted		18:50:00
DC-V13 observed on earth		18:53:39
DC-V2 transmitted		18:55:00
DC-V26 observed on earth		19:03:46
DC-V2 observed on earth		19:08:47
QC-V1-1 (minimum) transmitted		19:20:00
QC-V1-2 (minimum) transmitted		19:25:00
QC-V1-3 (minimum) transmitted		19:30:00
QC-V1-1 observed on earth		19:33:58
QC-V1-2 observed on earth		19:39:09
QC-V1-3 observed on earth		19:44:03
DC-V11 transmitted		19:45:00
DC-V11 observed on earth		19:59:11
DC-V4 transmitted		22:00:00
DC-V4 observed on earth		22:13:33
switch to data mode 1		22:14:58
switch to data mode 4		22:32:00
switch to data mode 1		22:48:00
switch to data mode 4		23:04:41
end of tape, data mode 1	20 Nov	16:01:45
switch to data mode 4		16:21:08
switch to data mode 1		16:37:08
DC-V2 transmitted		16:58:10

FLIGHT EVENT TIMES, 1967, GMT (Cont'd)

exercise to point the ultraviolet photometer (cont'd)

DC-V2 observed on earth	20 Nov	17:11:52
DC-V28 transmitted (turn on battery charger)		17:20:00
DC-V28 transmitted (turn off battery charger)		17:30:00
DC-V28 observed on earth		17:33:42
DC-V16 transmitted		17:35:00
DC-V28 observed on earth		17:43:47
DC-V16 observed on earth		17:48:49
condition spacecraft for long-term cruise		
DC-V9 (switch on ranging receiver) transmitted	21 Nov	15:51:00
DC-V15 transmitted		18:35:00
DC-V10 transmitted		18:40:00
DC-V9 (switch ranging receiver off) transmitted		18:45:00
DC-V15 observed on earth		18:49:09
DC-V10 observed on earth		18:54:11
DC-V12 transmitted		19:18:05
DC-V12 observed on earth		19:31:59
mission termination	1 Dec	

FLIGHT SEQUENCE (see Table 3)

FREQUENCY (see Radio)

FUEL (see Propulsion Subsystem)

FUNCTIONAL BLOCK DIAGRAMS OF SUBSYSTEMS (see Figs. 17–39)

GAS (see Attitude Control)

GYRO CONTROL SUBSYSTEM

gyros, number of	3
input angle storage capability (rate plus position mode)	6 deg
operating temperature range	30 to 131°F
operating rate range	±1 deg/s
power required	8.5 W
rate to position gain	
pitch and yaw	7 s
roll	12 s
reference designation of subsystem	7A2
weight (see also Table 7)	10.99 lb

HELIUM MAGNETOMETER

dynamic range	204.8 γ
electrical components, number of (see also Table 8)	1051
intervals between consecutive simultaneous-triaxial observations in one 50.4-s data frame, at 8-1/3 bps	7.2, 14.4, 10.8, and 18.0 s
location on spacecraft	on low-gain antenna
noise threshold	0.1 γ rms/axis
power required	7.21 W
reference designations of subassemblies (see Table 7)	
resolution of telemetered magnetic data	0.40 γ per axis
sensitivity threshold	$\leq$0.25 γ
sensors, number of	1 (measures 3 orthogonal axes)
spin rate	0.204 deg/s
weight (see also Table 9)	6.56 lb

HIGH-GAIN ANTENNA

back radiation	−20 to −80 dB
beam patterns (see Fig. 6)	
beamwidth at −3dB, major axis of pattern	
2116 MHz	15.2 deg
2298 MHz	14.8 deg
beamwidth at −3dB, minor axis of pattern	
2116 MHz	7.6 deg
2298 MHz	7.0 deg
beamwidth between first nulls, major axis of pattern	
2116 MHz	38.5 deg
2298 MHz	36.0 deg
beamwidth between first nulls, minor axis of pattern	
2116 MHz	19.5 deg
2298 MHz	17.5 deg
fundamental resonant frequency	120 Hz
line loss (between antenna assembly and electronics case)	
2116 MHz	0.25 dB
2298 MHz	0.28 dB
nominal peak gain (relative to right circular isotropic, referenced at the antenna assembly)	
2116 MHz	21.6 dB
2298 MHz	23.2 dB

HIGH-GAIN ANTENNA (Cont'd)

orientation of antenna boresight	
pre-encounter	
clock angle	107.4 deg
cone angle	110.7 deg
post-encounter	
clock angle	96.5 deg
cone angle	96.4 deg
parabolic reflector	
depth of parabola	8 in.
distance of feed from parabolic vertex	16 in.
ellipse major axis length	46 in.
ellipse minor axis length	21.2 in.
maximum deviation from true parabolic surface	0.040 in. (= 0.007 wavelength)
reflector material	aluminum honeycomb
performance analysis (see Fig. 16)	
polarization	right-hand circular
ellipticity on axis	
2116 MHz	5.5 dB
2298 MHz	0.4 dB
reference designation of subsystem	2E1
type	cupped turnstile feed and 2.06-to-1 elliptical parabolic reflector
voltage standing wave ratio	
2116 MHz	1.17 to 1
2298 MHz	1.28 to 1
weight, antenna assembly (including reflector)	4.91 lb
weight of parabolic reflector	3.99 lb

INSTRUMENTS, SCIENCE (see Dual Frequency Receiver, Helium Magnetometer, Plasma Probe, Trapped Radiation Detector, Ultraviolet Photometer)

KEY MILESTONE SUMMARY

project authorized	22 Dec 1965
payload selection completed	15 Feb 1966
engineering change requests and problem/failure report systems operating	15 Feb 1966
equipment released from the Spacecraft Assembly Facility (SAF) for modification	14 Mar 1966
spacecraft design established	22 Apr 1966

KEY MILESTONE SUMMARY (Cont'd)

thermal control model testing	22 Jun 1966 to 6 Jul 1966
structural test model testing	
test 1 start	18 Jul 1966
test 1 duration	4 weeks
test 2 start	6 Nov 1966
test 2 duration	10 days
flight support spacecraft (67-1) delivered to SAF	1 Oct 1966
last item delivered	14 Dec 1966
telemetry and command processor compatibility demonstrated	5 Dec 1966
flight spacecraft (67-2) delivered to SAF	15 Dec 1966
initial power application	6 Jan 1967
last item delivered	3 Feb 1967
system test 1	6 Feb 1967
simulated precountdown	23 Feb 1967
spacecraft/Agena interface test	27 Feb 1967
system test 2	7 Mar 1967
radio frequency/telemetry compatibility demonstrated	13 Mar 1967
vibration test	15 Mar 1967
space simulator test, part 1	23 Mar 1967
space simulator test, part 2	31 Mar 1967
system test 3	17 Apr 1967
shipment of Mariner V to AFETR	27 Apr 1967
AFETR testing and operations	
system test 4	3 May 1967
Explosive-Safe Facility mechanical preparation	3 May 1967
spacecraft mate to Agena adapter	25 May 1967
spacecraft moved to Launch Complex 12	31 May 1967
precountdown, spacecraft moved to ESF	2 Jun 1967
radio problem investigation	3 Jun 1967
spacecraft moved to Launch Complex 12	8 Jun 1967
precountdown	12 Jun 1967
flight events (see also Flight Event Times)	
launch	14 Jun 1967
midcourse maneuver	19 Jun 1967
encounter	19 Oct 1967
mission termination	1 Dec 1967

LOOK ANGLES

Canopus sensor	
cone direction	80--105.7 deg

LOOK ANGLES (Cont'd)

Canopus sensor (cont'd)	
clock direction	0 deg
earth sensor	
cone direction	132 deg
clock direction	270 deg
high-gain antenna (cone direction)	
pre-encounter	110.7 deg
post-encounter	96.4 deg
planet sensor	
cone direction	24° 54′
clock direction	0 deg
plasma probe	
cone direction	0 deg
sun gate, cone direction	0 deg
sun sensors, cone direction	0–180 deg
terminator sensor	
cone direction	110 deg
clock direction	110 deg
trapped radiation detector	
clock direction, all detectors	169 deg
cone direction, detector A	0 deg
cone direction, detectors B, C, and D	70 deg
ultraviolet photometer	
cone direction	90 deg
clock direction	95.5 deg

LOUVERS (see Temperature Control)

LOW-GAIN ANTENNA

ground plane diameter	7 in.
nominal peak gain (relative to right circular isotropic, referenced at the antenna connector)	
2116 MHz	6.0 dB
2298 MHz	5.0 dB
line loss (between antenna and electronics case)	
2116 MHz	0.18 dB
2298 MHz	0.23 dB
performance analysis (see Fig. 16)	
polarization	right-hand circular
ellipticity on axis	
2116 MHz	2.9 dB
2298 MHz	2.9 dB
reference designation of subsystem	2E2

LOW-GAIN ANTENNA (Cont'd)

type	circular wave-guide section terminating in a crossed slot aperture over a ground plane
voltage standing wave ratio	
2116 MHz	1.28 to 1
2298 MHz	1.25 to 1
waveguide	
inside diameter of	3.875 in.
length of	88 in.
thickness of tubing	0.025 in.
weight (antenna with mounting bracketry)	3.41 lb

MAGNETOMETER (see Helium Magnetometer)

MECHANICAL DEVICES SUBSYSTEM

cruise dampers and latches	
damping fluid	DC* 210 silicone oil
viscosity	1000 cS
damping ratio	0.15–0.70, matched to within 0.1
frequency of bus-panel system	0.5–5.0 Hz, all panels matched to 10%
number on spacecraft	4
weight (each)	0.22 lb
high-gain antenna pointing angle change (APAC) deployment mechanism	
antenna pointing angles	
clock	107.4 deg initial 96.5 deg, final
cone	110.7 deg, initial 96.4 deg, final
deployment time	200–250 ms
release method	pyrotechnically initiated pinpuller
rotation angle	17° 36′
springs	
material	302 stainless steel
number of	2
thickness	0.025 in.
torque (each)	8 in.-lb

*Dow Corning.

MECHANICAL DEVICES SUBSYSTEM (Cont'd)

high-gain APAC deployment mechanism (cont'd)	
springs (cont'd)	
type	coil clock
width	0.468 in.
weight	0.57 lb
low-gain antenna support dampers	
damping fluid	DC 210 silicone oil
viscosity	500,000 cS
material	
springs	beryllium copper
tubes	aluminum and uni-directional fiber glass tubing
nominal damping rate	
long damper	11 lb/in./s
short damper	5.5 lb/in./s
nominal spring rate	
long damper	320 lb/in.
short damper	160 lb/in.
weight	
long damper	0.39 lb
short damper	0.32 lb
pyrotechnic arming switch (PAS)	
functions	pyro arm pyro arm event Agena isolation amplifier off attitude control turn on pyro safe indication off
reference designation	8AS1
time of actuation	spacecraft separation
weight	0.1 lb
separation initiated timer (SIT)	
damping fluid	DC 210 silicone oil
viscosity	6000 cS
functions	backup pyro safe indication off at separation +30 ±20 s backup pyro arm at separation +30 ±20 s

MECHANICAL DEVICES SUBSYSTEM (Cont'd)

separation initiated timer (SIT) (cont'd)	
functions (cont'd)	pyro armed indication at separation +180 ±80 s
	solar panel and sun shade deployment at separation +190 ±80 s
reference designation	8M1
weight	0.6 lb
solar panel boost dampers	
damping fluid	DC 210 silicone oil
viscosity	30,000 cS
material	
springs	beryllium copper
tubes	hard-anodized aluminum
nominal damping rate	1.5 lb/in./s
nominal spring rate	20 lb/in.
number on spacecraft	4
unit weight	0.11 lb
solar panel deployment springs	
maximum allowable energy from sun shade deployment	4.0 in./lb
release method	pyrotechnically initiated pinpullers
springs	
active length	21.4 in.
material	Elgiloy
number per panel	2
thickness	0.025 in.
torque (each spring)	9 in.-lb stowed
	7.5 in.-lb deployed
type	coil clock
typical deployment time	6 s
weight per panel	0.32 lb

MIDCOURSE MANEUVER (see also Flight Event Times)

date	19 Jun 1967
time	23:08:06 to 23:08:23.66
day of flight	6
flight angle correction	0.3 deg
communication time (one way)	5.27 s
earth–spacecraft–sun angle	117.15 deg

MIDCOURSE MANEUVER (Cont'd)

Canopus–spacecraft–sun angle	76.72 deg
spacecraft celestial longitude	267.51 deg
spacecraft celestial latitude	−0.260 deg
earth celestial longitude	267.97 deg
Venus celestial longitude	223.37 deg
spacecraft distance from earth	1,581,615 km
	982,770 mi
spacecraft distance from sun	151,283,640 km
	94,003,290 mi
spacecraft distance from Venus	105,427,900 km
	65,509,840 mi
distance traveled along heliocentric arc	13,300,000 km
	8,243,000 mi
spacecraft velocity relative to earth	6,690 mph
spacecraft velocity relative to Venus	58 430 mph
spacecraft velocity relative to sun	60,451 mph
number of commands sent	6
total time for event	3 h, 16 min, 7 s
computed ideal parameters	
pitch turn	+55.35 deg
roll turn	+71.02 deg
motor burn time	17.6510 s
velocity increment	16.1272 m/s
command parameters	
pitch turn	+55.27 deg
roll turn	+70.95 deg
motor burn time	17.66 s
velocity increment	16.135 m/s
spacecraft actual performance	
pitch turn	+55.18 deg
roll turn	+70.93 deg
motor burn time	17.66 s
velocity increment	15.392 m/s
turn duration	
pitch	304 s
roll	380 s
turn rate	
pitch	+0.1818 deg/s
roll	+0.1867 deg/s

MIDCOURSE MANEUVER CONSTRAINTS

duration of first motor burn	<102.36 s
duration of turns	<1319 s

MIDCOURSE MANEUVER CONSTRAINTS (Cont'd)

end of turn	to occur outside interferometer region of low-gain antenna pattern
pitch turn restriction	at approximately 145×10^6 km
roll turn restriction	magnitude of turn must be small enough to permit transmission of DC-V13 if required
restrictions on earth–spacecraft vector	if terminator sensor activated, 20-deg half-cone angle to remain at 90- to 180-deg cone angle
restrictions on sun–spacecraft vector	if terminator sensor activated, 20-deg half-cone angle vector should not pass through field of view of Canopus sensor sun-shutter sensor if possible
sun position in relation to ultraviolet photometer field of view	sun not to pass within 5-deg half-cone angle of field of view

MT-1 CANOPUS CONE ANGLE UPDATE EVENT

date	24 Aug 1967
day of flight	72
time	08:41:08
cone angle setting	85.1 deg
communication time (one way)	1 min, 18 s
earth–spacecraft–sun angle	155.7 deg
Canopus–spacecraft–sun angle	83.2 deg
spacecraft celestial longitude	333.3 deg
spacecraft celestial latitude	−2.52 deg
earth celestial longitude	330.6 deg
Venus celestial longitude	327.3 deg
spacecraft distance from earth	23,341,070 km 14,503,469 mi
spacecraft distance from sun	129,662,180 km 80,568,343 mi

MT-1 CANOPUS CONE ANGLE UPDATE EVENT (Cont'd)

spacecraft distance from Venus	24,201,792 km 15,038,296 mi
distance traveled along heliocentric arc	177,752,162 km 110,472,690 mi
spacecraft velocity relative to earth	15,348.8 mph
spacecraft velocity relative to Venus	21,413.3 mph
spacecraft velocity relative to sun	71,630.0 mph

MT-2 CANOPUS CONE ANGLE UPDATE EVENT

date	10 Sep 1967
day of flight	88
time	00:41:26
cone angle setting	90.3 deg
communication time (one way)	1 min, 56 s
earth–spacecraft–sun angle	141.6 deg
Canopus-spacecraft–sun angle	87.8 deg
spacecraft celestial longitude	324.5 deg
spacecraft celestial latitude	−2.65 deg
earth celestial longitude	346.6 deg
Venus celestial longitude	353.5 deg
spacecraft distance from earth	34,915,052 km 21,695,207 mi
spacecraft distance from sun	121,731,330 km 75,640,340 mi
spacecraft distance from Venus	13,212,249 km 8,209,711 mi
distance traveled along heliocentric arc	226,342,582 km 140,642,760 mi
spacecraft velocity relative to earth	22,366.9 mph
spacecraft velocity relative to Venus	13,551.2 mph
spacecraft velocity relative to sun	76,144.5 mph

MT-3 CANOPUS CONE ANGLE UPDATE EVENT

date	26 Sep 1967
day of flight	105
time	16:42:43
cone angle setting	95.4 deg
communication time (one way)	2 min, 49 s
earth–spacecraft–sun angle	125.8 deg
Canopus-spacecraft–sun angle	93.3 deg
spacecraft celestial longitude	18.5 deg
spacecraft celestial latitude	−2.37 deg
earth celestial longitude	2.7 deg

MT-3 CANOPUS CONE ANGLE UPDATE EVENT (Cont'd)

Venus celestial longitude	19.7 deg
spacecraft distance from earth	50,836,609 km 31,588,404 mi
spacecraft distance from sun	114,470,020 km 71,128,374 mi
spacecraft distance from Venus	6,522,823 km 4,953,094 mi
distance traveled along heliocentric arc	274,839,713 km 170,777,480 mi
spacecraft velocity relative to earth	31,398.8 mph
spacecraft velocity relative to Venus	8,248.4 mph
spacecraft velocity relative to sun	80,564.0 mph

MT-4 CANOPUS CONE ANGLE UPDATE EVENT

date	10 Oct 1967
day of flight	119
time	14:04:14.4
cone angle setting	100.5 deg
communication time (one way)	3 min, 45 s
earth–spacecraft–sun angle	112.5 deg
Canopus–spacecraft–sun angle	98.0 deg
spacecraft celestial longitude	41.1 deg
spacecraft celestial latitude	−1.73 deg
earth celestial longitude	16.5 deg
Venus celestial longitude	42.1 deg
spacecraft distance from earth	67,503,928 km 41,944,996 mi
spacecraft distance from sun	109,869,090 km 68,269,484 mi
spacecraft distance from Venus	2,564,426 km 1,593,460 mi
distance traveled along heliocentric arc	319,265,219 km 198,382,210 mi
spacecraft velocity relative to earth	40,061.9 mph
spacecraft velocity relative to Venus	6,930.4 mph
spacecraft velocity relative to sun	83,561.1 mph

MT-5 CHANGEOVER TO HIGH-GAIN ANTENNA

date	1 Oct 1967
day of flight	109
time	16:43:33.8
communication time (one way)	3 min, 8 s
earth–spacecraft–sun angle	121.0 deg
Canopus–spacecraft–sun angle	95.0 deg
spacecraft celestial longitude	26.4 deg
spacecraft celestial latitude	−2.19 deg

MT-5 CHANGEOVER TO HIGH-GAIN ANTENNA (Cont'd)

earth celestial longitude	7.6 deg
Venus celestial longitude	27.7 deg
spacecraft distance from earth	56,494,636 km
	35,104,139 mi
spacecraft distance from sun	112,609,670 km
	69,972,406 mi
spacecraft distance from Venus	5,027,332 km
	3,123,839 mi
distance traveled along heliocentric arc	290,516,461 km
	180,518,560 mi
spacecraft velocity relative to earth	34,408.8 mph
spacecraft velocity relative to Venus	7,447.4 mph
spacecraft velocity relative to sun	81,749.9 mph

MT-6 CHANGEOVER TO 8-1/3 bps

date	24 Jul 1967
day of flight	41
time	19:19:21
communication time (one way)	35.4 s
earth–spacecraft–sun angle	147.9 deg
Canopus–spacecraft–sun angle	78.0 deg
spacecraft celestial longitude	299.5 deg
spacecraft celestial latitude	−1.63 deg
earth celestial longitude	300.9 deg
Venus celestial longitude	278.3 deg
spacecraft distance from earth	10,622,390 km
	6,600,447 mi
spacecraft distance from sun	142,858,570 km
	88,768,210 mi
spacecraft distance from Venus	57,234,319 km
	35,563,756 mi
distance traveled along heliocentric arc	96,431,352 km
	59,919,664 mi
spacecraft velocity relative to earth	7,754.8 mph
spacecraft velocity relative to Venus	38,604.7 mph
spacecraft velocity relative to sun	64,690.4 mph

MT-7 EVENT (see Flight Event Times, Table 25)

MT-8 BEGIN DAS ENCOUNTER SEQUENCE (see Flight Event Times)

MT-9 BEGIN PLAYBACK (see Flight Event Times)

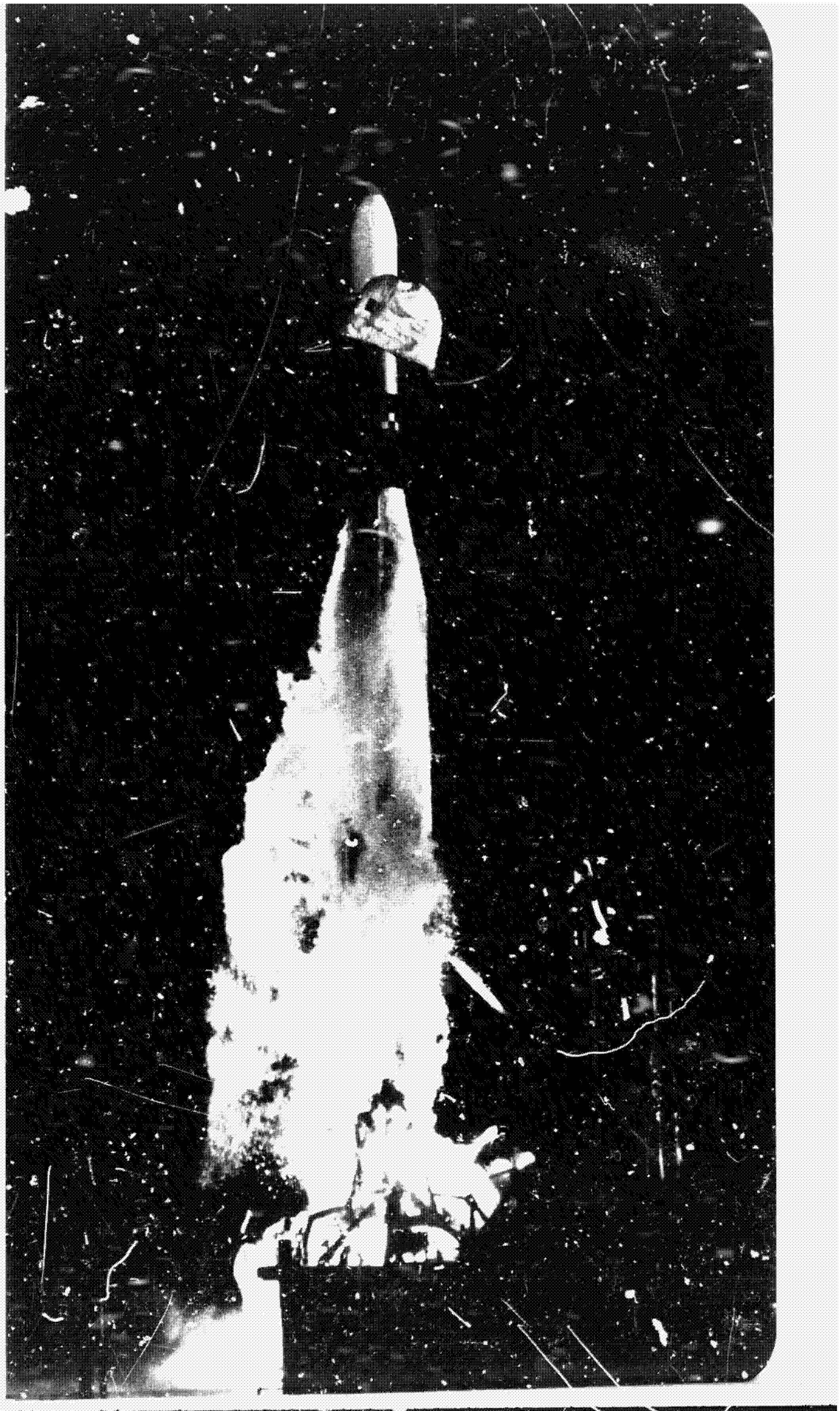
OCCULTATION EXPERIMENT

enter occultation	
time at spacecraft (19 Oct 1967)	17:31:36
time observed on earth	17:38:09
Venus time at point of entrance	between midnight and sunrise
altitude above Venus	4,175 km 2,594 mi
loss of signal	
time at spacecraft	17:34:42
time observed on earth	17:38:09
altitude above Venus	4,094 km 2,544 mi
acquisition of signal	
time at spacecraft	17:55:33
time observed on earth	17:59:59
altitude above Venus	6,785 km 4,216 mi
exit occultation	
time at spacecraft (19 Oct 1967)	17:58:04
time observed on earth	18:02:30
Venus time at point of emergence	near noon
altitude above Venus	7,339 km 4,560 mi
range rate accuracy	0.005 ft/s
ranging accuracy (average)	80 m 262 ft

ORBIT DATA, MARINER V

aphelion	
dates of	10 Apr 1968 22 Oct 1968
distance from sun	
10 Apr	109,888,340 km 68,281,446 mi
22 Oct	109,889,930 km 68,282,434 mi
celestial parameters	
astronomical unit	149,597,900 km 92,960,134 mi

Mariner V is launched from Cape Kennedy on 14 June 1967, at 06:01:00 GMT. The launch vehicle is an Atlas D/Agena D combination



ORBIT DATA, MARINER V (Cont'd)

celestial parameters (cont'd)	
radius of Venus used for orbit determination	6,056 km 3,763 mi
solar radiation constant used in orbit determinations	103,100,000 kg-km/s^2
universal constant of gravitation used in orbit determinations	0.6671×10^{-19} km^3/kg-s^2
celestial position (see also Table 5)	
sun–spacecraft inferior conjunction	28 Oct 1968
sun–spacecraft superior conjunction	30 Mar 1968 10 Jun 1969
closest approach to Venus (see also major heading, Encounter)	
altitude above Venus	4,094 km 2,544 mi
altitude above Venus, prior to midcourse maneuver	69,675 km 43,290 mi
date of	19 Oct 1967
distance from center of Venus	10,150.0 km 6,306.9 mi
encounter velocities and altitudes (see Fig. 53)	
time of	17:34:56
earth–spacecraft range (see also Tables 4 and 5)	
maximum range	259,528,540 km 161,263,560 mi
maximum range, date of	10 Apr 1968
minimum range, after encounter	38,995,007 km 24,230,374 mi
minimum range, date of	27 Oct 1968 27 Dec 1969
heliocentric orbit	
date of first completed trip around sun	29 Jan 1968
eccentricity of	0.1177
inclination to ecliptic before encounter	2.697 deg
inclination to ecliptic after encounter	1.385 deg
longitude of ascending node	114.11 deg
orbital period	194.61 deg
semimajor axis	98,320,366 km 61,093,326 mi
semiminor axis	97,637,399 km 60,668,951 mi
miscellaneous data	
aiming point diagram (see Fig. 41)	

ORBIT DATA, MARINER V (Cont'd)

miscellaneous data (cont'd)	
angle of celestial longitude of earth between launch and closest approach	123.12 deg
angle of celestial longitude of spacecraft between launch and closest approach	154.40 deg
B vector	
distance between initial aiming point (in B plane) and actual point hit	3,248 km 2,018 mi
inclination to Venus orbit	31.70 deg
closest approach to earth after encounter	
date of	27 Oct 1968
perihelion	
dates of	4 Jan 1968 17 Jul 1968
distance from sun	
4 Jan 1968	86,757,486 km 53,908,756 mi
spacecraft velocity relative to sun	92,491 mph

PLANET SENSOR

field of view (aligned at +41°4′clock)	4.55 × 1.55 deg
function	to initiate the science encounter sequence upon sensing the limb of Venus
look angle	
cone direction	24° 54′
clock direction	0 deg
location	above Bay VIII
power consumption	40 mW
sensitivity threshold	0.01 ft-cd
weight	0.57 lb

PLASMA PROBE

diameter of viewing aperture	2.5 in.
electrical components, number of (see also Table 8)	1494
field of view	15-deg half-angle cone
grids, number of	4
location on spacecraft	sun side, inboard of Bay III
look angle	
cone angle	0 deg

PLASMA PROBE (Cont'd)

measurement ranges (positive ions)	
flux density	5×10^{-5} to 5×10^{-9} particles cm^{-2} sec^{-1}
energy spectrum	30 eV to 10 keV
power required	
average	2.7 W (typ)
peak	2.90 W
reference designations of subassemblies (see Table 7)	
sensors, number of	1
weight (see also Table 9)	6.88 lb

POST-INJECTION PROPULSION SUBSYSTEM (see Propulsion Subsystem)

POWER SUBSYSTEM (see also Solar Panels)

battery	
life	1200 Wh
type	silver-zinc
number of cells	18
voltage (at full charge)	33 V
electrical components, number of, excluding solar cells (see also Table 8)	1064
inverters, number of	3
location of power regulator and battery	Bay VIII
location of power subsystem on spacecraft	Bay I
output voltages	
2.4-kHz square wave	50 V rms (+3, −2%)
400-Hz step square wave (to gyros)	27 V rms ±10% (3-phase)
power consumption (see Table 11)	(flight phase related)
reference designation of subassemblies (see Table 7)	
regulators, number of	2
regulator output voltage	52 Vdc ±1%
regulator power capability	150 W
solar panel power output (see Fig. 11)	
telemetry points, number of	23
weight, including solar panels	149.59 lb

PROPULSION SUBSYSTEM

burn time capability at launch	102 s
characteristic velocity	4340 ft/s
location on spacecraft	Bay II

PROPULSION SUBSYSTEM (Cont'd)

maximum thrust vector deflection capability, 2 jet vanes deflected 25 deg	±5.0 deg
motor thrust axis alignment to CG at launch	
horizontal offset	0.012 in.
vertical offset	0.001 in.
total offset	0.012 in.
motor tilt angle	1.5 deg
nozzle expansion ratio	44:1
number of ignitions possible	2
operating temperature range	+35 to +125°F
propellant flow rate	0.21487 lbm/s
reference designation of subsystem	10A1
specific heat ratio	1.38
stagnation chamber pressure	189.4 psia
throat area, ambient	0.15 $in.^2$
total ΔV capability	91.9 m/s
type of fuel	hydrazine
uncertainty in motor pointing accuracy	2.5 mrad, max
vacuum specific impulse (without jet vanes)	236.0 lbf-s/lbm
vacuum specific impulse, 4 jet vanes deflected 10 deg	232.7 lbf-s/lbm
vacuum thrust, without jet vanes	50.55 lbf
vacuum thrust, 4 jet vanes deflected 10 deg	49.19 lbf
vacuum thrust coefficient, without jet vanes	1.75
weight, subsystem (see also Table 9)	45.87 lb
weight, wet	
nitrogen gas	0.90 lb
oxidizer	0.11 lb
propellant	21.50 lb

PYROTECHNICS

electrical components, number of (see also Table 8)	240
pinpullers, number of	5
location on spacecraft	4 at solar panel tips 1 at high-gain antenna deployment mechanism
weight	0.25 lb ea
pyrotechnic control units	
power required	1.1 W
type	capacitor discharge
weight	8.03 lb
squibs	
all fire current	
10 single bridgewire	2.0 A

PYROTECHNICS (Cont'd)

squibs—all fire current (cont'd)	
10 dual bridgewire	3.3 A
number of (includes 10 used by propulsion subsystem)	20
weight of	0.50 lb
weight, subsystem (see also Table 9)	8.53 lb

RADIO (see also High-Gain Antenna, Low-Gain Antenna)

cavity amplifier output (nominal)	
preseparation	0.5 W (+27.0 dBm)
postseparation	7.1 W (+38.5 dBm)
traveling wave tube amplifier output, nominal	11.2 W (+40.5 dBm)
dc power input to cavity power amplifier	32 W, high-power mode 10 W, low-power launch mode
dc power input to traveling wave tube amplifier	61 W
dynamic range to threshold (nominal)	100 dB
electrical components, number of (see also Table 8)	1774
exciter output (nominal)	0.6 W (+28 dBm)
location of subsystem on spacecraft	Bays V and VI
noise temperature, including preselector (nominal)	2700°K
nominal downlink frequency for VCO mode (two-way lock at best lock frequency)	2297.593837 MHz at 25°C
nominal one-way transmission frequency at 25°C	
exciter A	2297.603093 MHz
exciter B	2297.609993 MHz
nominal uplink frequency for VCO mode (best lock frequency)	2115.700992 MHz at 25°C
radiated power increase, cavity to TWT	4.1 W (nominal)
reference designations of subassemblies (see Table 7)	
telecommunications performance analysis (see Fig. 16)	
threshold level, carrier (nominal)	−150 dBm
threshold level, command (nominal)	−141 dBm
weight, subsystem (see also Table 9)	39.18 lb
2.4-kHz power input to receiver	8 W
2.4-kHz power input to exciters and control unit	12 W

RANGING (see also Flight Event Times)

Mark I system (lunar)		
first turned on	20 Jun 1967	19:41:02
dropped below threshold	6 Jul 1967	15:00:02
distance from earth at threshold		6,000,000 km 3,728,000 mi
inherent accuracy (average)		45 m 147 ft
Mark II system (planetary)		
first turned on	21 Jun 1967	20:40:02
dropped below threshold	5 Nov 1967	17:51:02
distance from earth at threshold		100,000,000 km 62,137,000 mi
inherent accuracy (average)		80 m 262 ft

RECEIVER (see Radio)

REDUNDANCY (see Table 10)

REFERENCE DESIGNATIONS (see Table 7)

REVIEWS

system status (preliminary design)	17 Feb 1966
subsystem design	
pyrotechnics	12 Apr 1966
high-gain antenna	28 Apr 1966
data automation subsystem	26 May 1966
sensors	7 Jun 1966
dual-frequency receiver	10 Jun 1966
power subsystem	12 Jul 1966
ultraviolet photometer	28 Jul 1966
tape recorder	29 Jul 1966
thermal control	8 Aug 1966
solar panels	1 Apr and 27 Sep 1966
hardware reviews	following SAF delivery
67-1 status	9 Feb 1967
JPL pr[illegible]nping acceptance	21 Apr 1967
NAS[illegible]quarters review (quarterly)	
first (JPL)	13 Apr 1966
second (JPL)	15 Aug 1966
third (JPL)	14 Dec 1966
fourth (JPL)	10 April 1967
fifth, mission readiness (AFETR)	25 May 1967
sixth, midmission (Washington, D. C.)	3 Aug 1967

REVIEWS (Cont'd)

NASA headquarters review (quarterly) (cont'd)	
seventh, encounter readiness (JPL)	4 Oct 1967
eighth, post-encounter (Washington, D. C.)	13 Dec 1967

ROLL RATE

magnetometer calibration	3.5 mrad/s
Canopus search	2.0 mrad/s

SCIENCE SUBSYSTEMS

ancillaries	data automation subsystem
instruments, number of	5
instruments, (see also headings by instrument name and Table 6)	dual frequency receiver helium magnetometer plasma probe trapped radiation detector ultraviolet photometer
location of electronics on spacecraft	Bay III
power required by science instruments plus data automation subsystem	27.74 W
reference designations of science instruments (see Table 7)	
weight (see also Table 9)	49.37 lb

SENSORS (see Canopus Sensor, Earth Sensor, Planet Sensor, Terminator Sensor)

SEPARATION INITIATED TIMER (see Mechanical Devices Subsystem)

SOLAR PANELS (see also Power Subsystem)

cells	
type	p on n
material	boron-diffused silicon
number per panel	4410
number per section	1470
number of series cells per row	105
number of standard cells for telemetry monitoring	3
size of each solar cell	1 × 2 cm

SOLAR PANELS (Cont'd)

dimensions	
linear	44.40 × 35.5 in. (cell area; panel length = 74.98 in.)
area of each panel	10.9 ft^2
total solar panel area	43.6 ft^2
experimental solar cell outputs (see Fig. 12)	
panel sections	
area of each section	3.6 ft^2
number per panel	3
number of parallel rows per section	14
maximum voltage output per section	51 V
power	
output available	
near earth, at 55°C	405 W
at closest approach	620 W
reference designations of subassemblies (see Table 7)	
solar distance	
at earth	1.49 × 10^8 km
at Venus	1.08 × 10^8 km
solar energy	
near earth	135 mW/cm^2
near Venus	255 mW/cm^2
weight of each panel	15.3 lb (solar panel only)

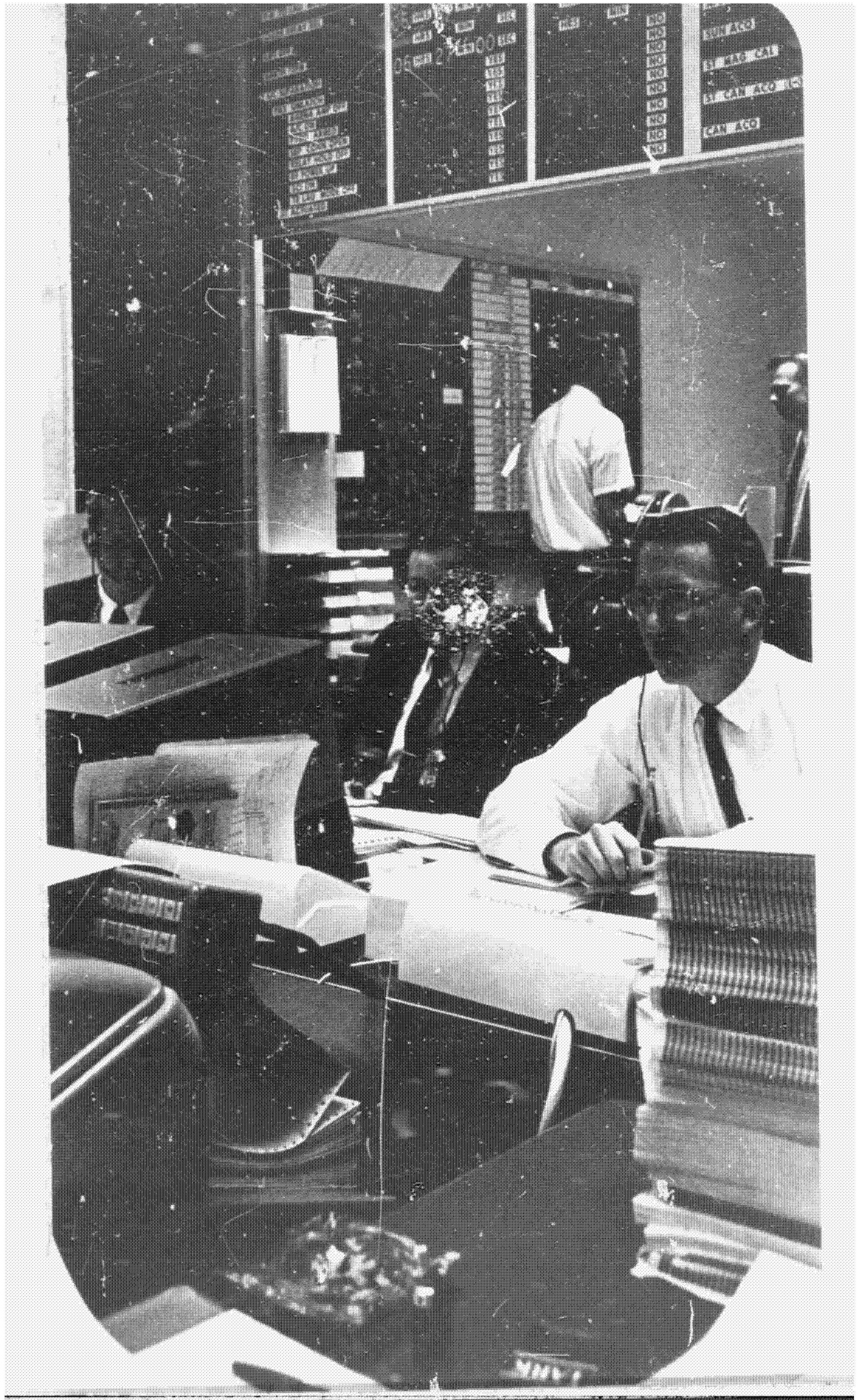
SPACECRAFT

clock angle 0-deg reference	Canopus sensor view direction, Bay VIII, 45 deg from −Y axis, 45 deg from +X axis
configuration (see Figs. 1 and 2)	
dimensions	
overall height	9.5 ft
span with solar panels extended	16.3 ft
width of octagon (at points)	54.5 in.
electrical components, total number of (see also Table 8)	47,342
functions with alternate operations, number of	18
options available for 18 functions, number of	53
redundant items (see Table 10)	

SPACECRAFT (Cont'd)

spacecraft center of gravity positions	
boost configuration	
X axis	+0.79 in.
Y axis	+0.21 in.
Z axis	−18.83 in.
cruise (pre-midcourse) configuration	
X axis	+0.77 in.
Y axis	+0.29 in.
Z axis	−12.14 in.
cruise (post-midcourse) configuration	
X axis	+0.72 in.
Y axis	+0.23 n.
Z axis	−12.16 in.
spacecraft magnetic field (at magnetometer, without solar panels)	
magnetometer X axis	−1.0γ
magnetometer Y axis	+2.6γ
magnetometer Z axis	+7.1γ
spacecraft moments and products of inertia	
boost configuration	I_X = 84.94 slug ft²
	I_Y = 80.94 slug ft²
	I_Z = 49.32 slug ft²
	I_{XY} = −3.60 slug ft²
	I_{XZ} = +1.60 slug ft²
	I_{YZ} = +1.05 slug ft²
cruise (pre-midcourse) configuration	I_X = 73.60 slug ft²
	I_Y = 71.08 slug ft²
	I_Z = 124.48 slug ft²
	I_{XY} = −3.24 slug ft²
	I_{XZ} = +1.03 slug ft²
	I_{YZ} = +0.96 slug ft²
cruise (post-midcourse) configuration	I_X = 73.54 slug ft²
	I_Y = 71.02 slug ft²
	I_Z = 124.38 slug ft²
	I_{XY} = −3.28 slug ft²
	I_{XZ} = +1.01 slug ft²
	I_{YZ} = +0.94 slug ft²

SPAC team at work at JPL, evaluating Mariner V performance



SPACECRAFT (Cont'd)

temperatures vs time (see Figs. 13–15)	
total number of parts	97,130
assembled cables	30
electrical components (see also Table 8)	44,486
excluding integrated circuits	24,674
594 integrated circuits × 33.5 (1 integrated circuit = 33.5 conventional components)	19,812
mechanical, electromechanical and other	52,614
weight (see also Table 9)	539.17 lb

SQUIBS (see Pyrotechnics)

STAR MAP

number of stars stored in computer	423 + Milky Way and zodiacal light

STRUCTURE SUBSYSTEM

electronic assembly chassis (see also Fig. 3)	
location	Bays I and III through VII
material	ZK-60 magnesium
volume for electronics	two vertical spaces per bay: 6 in. wide by 16.5 in. high
weight	4.19 to 4.59 lb
high-gain antenna structure	
dimensions, parabolic reflector	
ellipse major axis length	46 in.
ellipse minor axis length	21.2 in.
material	
feed support truss	Lexan end fittings, unidirectional fiber glass tubing
parabolic reflector	aluminum honeycomb 0.0007-in. core 0.0035-in. face skins
low-gain antenna structure	
dimensions, waveguide	
inside diameter	3.875 in.
length	88 in.
thickness	0.025 in.
material	
ground plane	aluminum honeycomb
waveguide	6061 aluminum tube

STRUCTURE SUBSYSTEM (Cont'd)

octagon structure	
adapter attach feet	
quantity	8
width (each)	1.00 in.
construction	machined upper and lower rings tied together by machined longerons
diameter	
across flats	50.35 in.
maximum	55.08 in.
height	18.0 in.
material	ZK-60 magnesium
weight	34.5 lb
propulsion support structure	
location	Bay II
material	6061-T6 aluminum
motor thrust axis adjustment capability	0–4 deg (86- to 90-deg cone angle) ±1/2 in. laterally, 3/8 in. upward, 1/4 in. down
weight	2.25 lb
solar panel structure	
adhesive	Epon 913
dielectric material	Epon 956 and 2-mil glass cloth
length	
celled surface	44.40 in.
overall	74.98 in.
material	0.005-in. aluminum face skin and corrugations
weight of structure	9.7 lb
width	
celled surface	35.5 in.
superstructure	
construction	swaged thin-wall tubes riveted to machined end fittings
function	mounts high-gain antenna to octagon

STRUCTURE SUBSYSTEM (Cont'd)

superstructure (cont'd)	
material	6061-T6 aluminum
weight	3.25 lb

SUBSYSTEMS (see Attitude Control, Cabling, Central Computer and Sequencer, Command, Data Automation Subsystem, Data Encoder, Dual Frequency Receiver, Dual Frequency Receiver Antennas, High-Gain Antenna, Low-Gain Antenna, Mechanical Devices, Power, Propulsion, Pyrotechnics, Radio, Science, Structure, Tape Recorder, Temperature Control)

SUN GATE

field of view	2.2-deg half-angle cone
number of sun gates	1
number of cells	2
sun acquisition time	20 min (maximum)

SUN SENSORS

field of view	
primary sun sensor	± 2 deg each axis
secondary sun sensor	4π sr
number of sensor assemblies	4
number of sensor cells	16
number of primary cells	4
number of secondary cells	12
reference designations of subassemblies (see Table 7)	

TAPE RECORDER

bit capacity	1×10^6
bit error rate	<1 in 10^5 bits
electrical components, number of (see also Table 8)	1479
location on spacecraft	Bay V
number of tracks recording simultaneously	2
operating temperature range	-10 to 70°C
playback frequency	8-1/3 bps
playback times	
track 1	17h, 48min, 35s
track 2	18h, 4min, 47s

TAPE RECORDER (Cont'd)

power required, nominal (2400 Hz)	3.4 W, launch
	6.0 W, playback
	7.1 W, record
	4.6 W, standby
record frequency	66-2/3 bps
record-to-playback speed ratio	8:1
recording sequence (see Fig. 29)	
record times	
track 1	127min, 22s
track 2	107min, 32s
reference designations of subassemblies (see Table 7)	
tape length	53-ft loop
tape speed, playback	0.01 in./s
tape speed, record	0.08 in./s
tape width	0.25 in.
total recording time during encounter	2h, 7min
weight, subsystem (see also Table 9)	19.35 lb

TELEMETRY

channel allocations, 7-bit words (see also Table 21)	
scientific	
data mode 2	40 words
data mode 3	60 words
engineering	90 words
communications measurements	11
current measurements	13
deck syncs	3
event counters	4 (2 words)
position measurements	13
pressure measurements	7
spare	3
temperature measurements	33
voltage measurements	5
data frames	
bits per high-rate data frame	
mode 1	140
mode 2	420
cycle time (8-1/3 bps)	
mode 1	16.8 s
mode 2	50.4 s
cycle time (33-1/3 bps)	
mode 1	4.2 s
mode 2	12.6 s

TELEMETRY (Cont'd)

data frames (cont'd)		
number of compiete science measurements per data frame	Mode 2	Mode 3
dual frequency receiver	2	2
helium magnetometer	9	15
plasma probe	6	6
trapped radiation detector	3	3
ultraviolet photometer	3	9
data modes, number of	4	
data mode formats		
data mode 1		
science bits per data frame	0	
engineering bits per data frame	140	
data mode 2		
science bits per data frame	280	
engineering bits per data frame	140	
data mode 3		
science bits per data frame	406	
engineering bits per data frame	14	
data mode 4		
science bits per data frame	160	
number of data tracks	2 (non-real-time data)	
encoding type	sampled data, digital phase-shift-keying with pseudonoise synchronization	
engineering format (see Fig. 23)		
error probabilities		
bit error probability at threshold	5×10^{-3}	
required ST/N/B* for bit error probability of 5×10^{-3}	$+7.6 \pm 1.2$ dB	
word error probability at threshold	1 word in 28	
time between samples (see Table 22)		
transmission rates	33-1/3, 8-1/3 bps	
word length	7 bits	

*Signal power per bit to noise power in unit bandwidth.

TEMPERATURE CONTROL

assemblies, number of	40
louvers	
angular change of louvers relative to temperature	90 deg/30°F
louver area for each bay	1.4 ft²
total louver area	8.4 ft²
louver positioning error	±5 deg
number of bays with louvers	6
number per assembly	22 (11 pairs)
total number of louvers	128
weight of all louvers	8.16 lb
parts, number of in system	1200
shielding	
amount of octagon covered by shielding	85%
material of blanket layers	0.0005-in. aluminized Mylar
numbers of layers in lower blanket	19
number of layers in upper blanket	13
weight of thermal passive-type shielding	7.5 lb
sun shade	
area	12 ft²
material	0.001-in. aluminized Teflon
method of deployment	lanyard release from solar panels
springs	
number of	8
torque	1 in.-lb
weight	0.98 lb
weight, subsystem (see also Table 9)	17.25 lb

TEMPERATURE CONTROL REFERENCE

detector	platinum resistance thermometer
function	measures paint-sample temperature
location and sample types on spacecraft	
+X panel	S-13 white
−Y panel	Cat-a-Lac black
−X panel	S-13M white
nominal properties (see Table 12)	
number on spacecraft	3
weight (each unit)	0.1 lb

TERMINATOR SENSOR

encounter geometry (see Fig. 10)	
field of view	1.5 deg clock
	2.5 deg cone
look angle	110 deg cone
	110 deg clock
weight	0.16 lb
sensitivity threshold	0.1 ft-cd
function	to trigger high-gain antenna pointing angle change upon sensing the terminator of Venus

TESTING

environmental tests (see Tables 14–18)
system tests (see Table 19)

THERMAL SHIELDS (see Temperature Control)

THRUST (see Propulsion Subsystem)

TIMING (see Central Computer and Sequencer)

TRAJECTORY (see Figs. 40–54)

TRAPPED RADIATION DETECTOR

counting rates	
detectors A, B, C	0.6 to 10^7 counts/s
detector D	0.071 to 10^6 counts/s
detection levels (number of detectors)	4
electrical components, number of (see also Table 8)	417
field of view (all detectors)	30-deg half-angle cone
geometric factor, omnidirectional	
detector A	approx 0.15 cm^2
detector B	approx 0.15 cm^2
detector C	approx 0.15 cm^2
geometric factor, unidirectional	
detector A	0.044 $\pm$0.005 cm^2 sr
detector B	0.055 $\pm$0.005 cm^2 sr
detector C	0.050 $\pm$0.005 cm^2 sr
detector D	0.065 $\pm$0.003 cm^2 sr
location on spacecraft	above Bay IV
look angle	
detector A	
axis relative to spacecraft–sun line	0 deg
full look angle	10 deg

TRAPPED RADIATION DETECTOR (Cont'd)

look angle (cont'd)		
detectors B, C, D		
axis relative to spacecraft–sun line		70 deg
full look angle (det B and C)		60 deg
full look angle (det D)		80 deg
measurement ranges		
detector A	electrons	$>$95 keV
	protons	$>$2.7 keV
	X-rays	$\lambda < 10$ Å
detector B	electrons	$E_e > 45$ keV
	protons	$E_p > 0.65$ MeV
detector C	electrons	$E_e > 150$ keV
	protons	$E_p > 3.1$ MeV
detector D	electrons	insensitive to any energy
	protons	D_1 0.30 $< E_p <$ 12 MeV
		D_2 0.50 $< E_p <$ 5.3 MeV
		D_3 0.98 $< E_p <$ 2.2 MeV
	alpha particles	D_4 2.1 $< E_\alpha <$ 18 MeV
power required		0.5 W
sensors, number of		4
weight (see also Table 9)		2.63 lb

TRAVELING WAVE TUBE AMPLIFIER (see Radio)

TRAVELING WAVE TUBE AMPLIFIER CHANGEOVER

date	27 Jun 1968
day of flight	13
time	00:27:00
communication time (one way)	11.27 s
earth–spacecraft–sun angle	122.7 deg
Canopus–spacecraft–sun angle	76.6
spacecraft celestial longitude	273.8 deg
spacecraft celestial latitude	−0.551 deg
earth celestial longitude	274.7 deg
Venus celestial longitude	234.6 deg
spacecraft distance from earth	3,380,809 km 2,100,737 mi
spacecraft distance from sun	150,219,438 km 93,341,817 mi

TRAVELING WAVE TUBE AMPLIFIER CHANGEOVER (Cont'd)

spacecraft distance from Venus	92,255,438 km 59,188,984 mi
distance traveled along heliocentric arc	31,052,281 km 19,294,993 mi
spacecraft velocity relative to earth	6,587 mph
spacecraft velocity relative to Venus	54,381 mph
spacecraft velocity relative to sun	61,035 mph

ULTRAVIOLET PHOTOMETER

comparison of tubes B and C	hydrogen, 1216 Å
comparison of tubes A and B	oxygen, 1304 Å
data rate	33-1/3 bps and 8-1/3 bps
dynamic range	0.7 to 100.0 kilorayleighs
electrical components, number of (see also Table 8)	1223
field of view	
Tubes A and B	1 deg solid cone
Tube C	2-1/2 deg solid cone
location on spacecraft	above Bay 11
power required	4.6 W
sensitivity	700 rayleighs at 1216 Å
sensors, number of	3 phototubes
spectral range	
Tube A, calcium fluoride filter	1250–1900 Å
Tube B, barium fluoride filter	1350–1900 Å
Tube C, lithium fluoride filter	1050–1900 Å
weight (see also Table 9)	9.21 lb

VELOCITY AT ENCOUNTER (see Fig. 53)

VELOCITY OF MARINER V RELATIVE TO EARTH

periodically during flight (see Table 4)

injection	14 Jun	25,501 mph
midcourse maneuver	19 Jun	6,690 mph
changeover to traveling wave tube amplifier	27 Jun	6,587 mph
MT-6 changeover to 8-1/3 bps	24 Jul	7,755 mph
MT-1 Canopus cone angle update	24 Aug	15,349 mph
MT-2 Canopus cone angle update	10 Sep	22,367 mph
MT-3 Canopus cone angle update	26 Sep	31,399 mph

VELOCITY OF MARINER V RELATIVE TO EARTH (Cont'd)

MT-5 changeover to high-gain antenna	1 Oct	34,409 mph
MT-4 Canopus cone angle update	10 Oct	40,062 mph
closest approach	19 Oct	56,696 mph
end of mission	1 Dec	86,224 mph

VELOCITY OF MARINER V RELATIVE TO SUN

periodically during flight (see Table 4)		
midcourse maneuver	19 Jun	60,451 mph
changeover to traveling wave tube amplifier	27 Jun	61,035 mph
MT-6 changeover to 8-1/3 bps	24 Jul	64,690 mph
MT-1 Canopus cone angle update	24 Aug	71,630 mph
MT-2 Canopus cone angle update	10 Sep	76,144 mph
MT-3 Canopus cone angle update	26 Sep	80,564 mph
MT-5 changeover to high-gain antenna	1 Oct	81,750 mph
MT-4 Canopus cone angle update	10 Oct	83,561 mph
closest approach	19 Oct	85,003 mph
end of mission	1 Dec	85,513 mph
at perihelion of heliocentric orbit	4 Jan 1968	92,491 mph
at aphelion of heliocentric orbit	10 Apr 1968	73,022 mph

VELOCITY OF MARINER V RELATIVE TO VENUS

periodically during flight (see Table 4)		
midcourse maneuver	19 Jun	58,430 mph
changeover to traveling wave tube amplifier	27 Jun	54,381 mph
MT-6 changeover to 8-1/3 bps	24 Jul	38,605 mph
MT-1 Canopus cone angle update	24 Aug	21,413 mph
MT-2 Canopus cone angle update	10 Sep	13,551 mph
MT-3 Canopus cone angle update	26 Sep	8,248 mph
MT-5 changeover to high-gain antenna	1 Oct	7,447 mph
MT-4 Canopus cone angle update	10 Oct	6,930 mph
closest approach	19 Oct	19,157 mph
end of mission	1 Dec	16,655 mph

VENUS

albedo (λ5500 Å)	0.6 min 0.76 max
cloud top temperature	200°K
density	5.35 g/cm^3
mass	4.870×10^{27} g

VENUS (Cont'd)

radius (solid surface)	6080 ±10km*
rotation period	250 ±40 days retrograde
surface gravity	900 cm/s^2
surface pressure	20 ±2 bars*
surface temperature	550 ±20°K*

VOLTAGE-CONTROLLED OSCILLATOR (see Radio)

WEIGHT

subsystem weights (see Table 9)	
total spacecraft weight	539.17 lb

*Based upon the Soviet Union's Venus 4 data. See also Table 1.

TABLES

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Table 1. Comparison of Venus missions

Mission	Encounter date	Flight time, days	Communication distance, Gm
Mariner II flyby	12/14/62	109.5	57.8
Venus 2 flyby	2/27/66	107	59.2
Venus 3 impacter	3/1/66	105	61.4
Venus 4 lander	10/18/67	128.5	77.9
Mariner V flyby	10/19/67	127.5	79.76

NOTE: Venus 3 impacted within a few minutes of the time that it reached the Moscow zenith, but the Venus 2 flyby occurred 4 h before zenith passage. Venus 2 is reported to have passed 24,000 km above the planet surface; the corresponding number for Mariner II was 34,854 km, an or Mariner V was 4,094 km.

Table 2. Time conversion guide

GMT	EDT	EST	PDT	PST	Tidbinbilla	Woomera	Madrid and So. Africa
0100	2100	2000	1800	1700	1100	1030	0300
0200	2200	2100	1900	1800	1200	1130	0400
0300	2300	2200	2000	1900	1300	1230	0500
0400	2400	2300	2100	2000	1400	1330	0600
0500	0100	2400	2200	2100	1500	1430	0700
0600	0200	0100	2300	2200	1600	1530	0800
0700	0300	0200	2400	2300	1700	1630	0900
0800	0400	0300	0100	2400	1800	1730	1000
0900	0500	0400	0200	0100	1900	1830	1100
1000	0600	0500	0300	0200	2000	1930	1200
1100	0700	0600	0400	0300	2100	2030	1300
1200	0800	0700	0500	0400	2200	2130	1400
1300	0900	0800	0600	0500	2300	2230	1500
1400	1000	0900	0700	0600	2400	2330	1600
1500	1100	1000	0800	0700	0100	0030	1700
1600	1200	1100	0900	0800	0200	0130	1800
1700	1300	1200	1000	0900	0300	0230	1900
1800	1400	1300	1100	1000	0400	0330	2000
1900	1500	1400	1200	1100	0500	0430	2100
2000	1600	1500	1300	1200	0600	0530	2200
2100	1700	1600	1400	1300	0700	0630	2300
2200	1800	1700	1500	1400	0800	0730	2400
2300	1900	1800	1600	1500	0900	0830	0100
2400	2000	1900	1700	1600	1000	0930	0200

Table 3. Flight sequence

Event No.	Anticipated time[a]	Earth-observed time, GMT, day:h:min:s	Description
1	T −15 min		Verify CC&S update pulses
2	T −7 min	165:05:54:00	Switch to internal power
3	T −7 min	:05:55:00	Insert CC&S update pulses (88)
4	T −5 min	:05:56:00	Launch complex equipment relay hold off
5	T −4 min	:05:56:28	Tape recorder to launch mode
6	T −3 min	:05:58:00	Release CC&S real-time inhibit
7	T −1 min	:05:59:59	Clear relay released
8	T = 0	:06:01:00.176	Liftoff
9	T +5 min	:06:06:20.24	Nose fairing separation
10	I = T +30 min	:06:24:35.50	Spacecraft injection
11	S = T +32.6 min	:06:27:16.90	Spacecraft separation pyro arming switch unlatched Agena isolation amplifier off attitude control on pyro armed

Table 3. (Cont'd)

Event No.	Anticipated time[a]	Earth-observed time, GMT, day:h:min:s	Description
11 (cont'd)	S = T +32.6 min	165:06:27:16.90	separation connector opened relay hold off RF power up science on
	S +0.1 min	:06:27:16.90	tape recorder launch mode off
		:06:30:12	separation initiated timer actuated
12	S +~30 s	performed by PAS	Arm pyro (SIT)
13	S +~3 min	:06:30:19.01	Deploy solar panels (SIT)
14	T +53 min	:06:53:56.6	Deploy solar panels (L-1)
15	T +57 min	:06:57:56.0	Turn on attitude control (L-2)
16	S +23 min	:06:44:23	Sun acquired
17	T +1 h	:06:44:23	Start magnetometer calibration
18	T +16.6 h	:22:38:00.5	Begin Canopus acquisition (L-3)
19	T +~17 h	166:01:09:13	Canopus acquired
20	T +2 to 10 days	170:20:18:00	Begin trajectory correction maneuver send QC-V1, DC-V29 DC-V14, DC-V27

	M = 0	:21:24:46	switch to data mode 1, CC&S M-1
	M +1 h	:22:24:10.9	start pitch turn (M-4)
	M +1 h 22 min	:22:29:14.8	stop pitch turn
	M +1 h 22 min	:22:46:10.8	start roll turn (M-5)
	M +1 h 44 min	:22:52:31.2	stop roll turn
	M +1 h 44 min	:23:08:11.3	start motor burn (M-6)
	M +1 h 45.7 min	:23:08:28	stop motor burn (M-7)
21	M +1 h 50 min	:23:14:10.9	Begin reacquisition ($\overline{\text{M-1}}$, $\overline{\text{M-2}}$) switch to data mode 2
22	M +2 h 10 min	:23:21:24.2	Sun acquired
23	M +3 h 10 min	171:00:23:58.4	Canopus acquired
24	M +3 h 19 min	:00:43:12	Maneuver counter off
25	M +3 h 30 min	:02:19:00	Send minimum QC-V1
26	T +10 days	178:00:28:00	Transfer to traveling wave tube amplifier (DC-V7)
27			Second trajectory correction maneuver (if required)
28	E −87 days	205:19:19:21.4	Switch to 8-1/3 bps (MT-6)
29	E −56.4 days	236:08:41:32.8	Update Canopus cone angle (MT-1)
30	E −39.7 days	253:00:41:51.5	Update Canopus cone angle (MT-2)

Table 3. (Cont'd)

Event No.	Anticipated time[a]	Earth-observed time, GMT, day:h:min:s	Description
31	E −23.0 days	269:16:42:43	Update Canopus cone angle (MT-3)
32	E −18.5 days	274:16:43:33.8	Switch to transmit high, receive low (MT-5)
33	E −9.2 days	283:14:04:14.4	Update Canopus cone angle (MT-4)
34	E −19-1/3 h	291:22:05:13.9	Turn off ranging (CY-1)
35	E −15 h	292:02:49:00	Begin encounter sequence (DC-V25) tape recorder power on terminator sensor power on science on; overload inhibit override energize DAS APAC command circuit
36	E −12-2/3 h	:04:45:05.8	Backup: begin encounter sequence (MT-7)
37	E −6-3/4 h	:10:50:00	Begin data automation subsystem encounter mode (DC-V24)
38	E −6 h	:11:25:03.6	Backup: begin DAS encounter mode (MT-8) switch to data mode 3 planet sensor power on switch plasma probe to data mode 3
39	E −[illegible]	:15:01:43	Turn on DAS timer A (DC-V16)

40	E −1 h	:16:33:57 ± 25.2 s	Venus acquired (PSO) inhibit ultraviolet photometer calibrate begin recording data on track 1 start DAS timer B
41	E −46.5 min	:16:46:46	Start recording dual frequency receiver data (track 2)
42	E −5 min	:17:38:09	Enter S-band occultation
43	E = 0	:17:34:55.8	Closest approach to Venus
44	E +8 min	:17:46:51.4	Antenna pointing angle change (APAC)
45	E +21 min	:17:59:59	Exit occultation
46	E +1:01 h	:18:34:18	Stop recording DFR data (track 2)
47	E +1:10 h	:18:41:51	Tape recorder off (end of tape)
48	E +1:15 h	:18:48:18	Switch to data mode 2 planet sensor power off enable ultraviolet photometer calibration switch plasma probe to cruise mode
49	ASAP after event 43	not required	Send APAC command (DC-V22)
50	ASAP after event 43	292:19:00:00	Turn on ranging (DC-V9)
51	E +14 h	293:07:25:23.4	Switch to data mode 4 (MT-9)
52	E +32.2 h	294:01:13:01	Switch tape recorder tracks (end of tape)

Table 3. (Cont'd)

Event No.	Anticipated time*	Earth-observed time, GMT, day:h:min:s	Description
53	E +1 day, 23-1/3 h	294:16:55:58	Turn off ranging (CY-1)
54	E +2 days, 2.4 h	:18:18:30	End of first data playback
55	E +2 days, 2.4 h	:19:18:17	Start second data playback
56	E +2 days, 2.9 h	:18:45:00	Turn on ranging (DC-V9)
57	E +2 days, 20.6 h	295:13:06:52	Switch tape recorder tracks (end of tape)
58	E +3 days, 14.8 h	296:06:11:50	End of second data playback
59	E +3 days, 14.8 h	:07:55:00	Switch to data mode 2
60	E +3 days, 14.8 h		Turn on ranging (after CY-1s)

*T = liftoff
I = spacecraft injection
S = spacecraft separation
M = midcourse maneuver
E = encounter

Table 4. Mariner V ranges and velocities

Calendar day	Date	Spacecraft range, mi			Spacecraft velocity, mph		
		Earth altitude	Venus altitude	Sun distance	Relative to earth	Relative to Venus	Relative to sun
165	6/14/67	140,074[a]	70,047,611	94,357,108	7,747	61,647	59,437
172	6/21/67	984,565	65,473,765	94,000,461	6,688	58,409	60,454
179	6/28/67	2,175,793	58,736,653	93,286,644	6,585	54,094	61,080
186	7/5/67	3,282,053	52,493,623	92,401,456	6,606	50,077	61,788
193	7/12/67	4,3[illegible]7,283	46,368,525	91,310,105	6,735	46,059	62,653
200	7/19/67	5,546,445	40,436,058	90,021,286	7,123	42,042	63,681
207	7/26/67	6,780,203	34,769,333	88,546,708	7,885	38,032	64,870
214	8/2/67	8,158,305	29,438,183	86,901,492	8,989	34,044	66,216
221	8/9/67	9,740,270	24,507,515	85,104,823	10,440	30,098	67,713
228	8/16/67	11,594,127	20,035,252	83,180,735	12,320	26,223	69,349
235	8/23/67	13,796,912	16,069,383	81,158,999	14,624	22,460	71,107
242	8/30/67	16,409,561	12,643,434	79,076,052	17,274	18,866	72,966
249	9/6/67	19,471,613	9,769,415	76,975,811	20,251	15,521	74,891
256	9/13/67	23,012,660	7,427,794	74,910,186	23,616	12,533	76,839

Table 4. (Cont'd)

Calendar day	Date	Spacecraft range, mi			Spacecraft velocity mph		
		Earth altitude	Venus altitude	Sun distance	Relative to earth	Relative to Venus	Relative to sun
263	9/20/67	27,053,338	5,556,761	72,938,918	27,364	10,051	78,753
270	9/27/67	31,584,441	4,049,241	71,128,374	31,398	8,248	80,563
277	10/4/67	36,566,355	2,769,607	69,548,786	35,637	7,239	82,191
284	10/11/67	42,132,131	1,549,575	68,231,598	40,217	6,929	83,603
291	10/18/67	47,644,538	416,181	67,349,800	44,766	7,170	84,756
298	10/25/67	52,539,616	847,345	66,435,992	46,483	7,038	75,247
305	11/1/67	56,861,451	1,951,234	65,393,239	52,499	7,203	76,586
312	11/8/67	61,855,081	3,212,915	64,071,545	59,338	7,984	78,272
319	11/15/67	67,233,023	4,659,629	62,584,241	66,647	9,543	80,203
326	11/22/67	73,015,333	6,423,244	60,988,481	74,432	11,929	82,324
333	11/29/67	79,194,680	8,628,568	59,356,608	82,621	15,087	84,552
335	12/1/67	81,028,610	9,353,511	58,895,573	85,018	16,118	85,193

[a]22:10:00 GMT; all other times 00:00:00 GMT.

Table 5. Earth and spacecraft positions, December 1967 through December 1971

Date	Spacecraft celestial position		Spacecraft distance from earth		Spacecraft distance from sun	
	Longitude, deg	Latitude, deg	km	mi	km	mi
Dec 1, 1967	130.9	0.40	132,927,590	82,597,376	94,150,677	58,502,518
10	149.6	0.80	146,895,360	91,276,544	91,070,527	56,588,601
20	171.7	1.17	163,076,770	101,331,200	88,396,333	54,926,934
30	194.9	1.37	179,308,770	111,417,300	86,936,669	54,018,941
Jan 9, 1968	218.4	1.34	194,814,890	121,052,360	86,964,202	54,037,049
19	241.6	1.10	208,951,920	129,836,700	88,473,431	54,974,841
29	263.6	0.70	221,305,300	137,512,740	91,182,972	56,658,471
Feb 8	284.2	0.24	231,729,020	143,989,730	94,645,856	58,810,208
18	303.3	−0.22	240,304,780	149,318,470	98,385,176	61,136,713
28	320.9	−0.63	247,165,400	153,581,460	101,984,790	63,376,413
Mar 9	337.5	−0.96	252,427,760	156,851,340	105,123,270	65,320,573
19	353.2	−1.19	256,213,250	159,203,530	107,572,380	66,842,379
29	8.3	−1.34	258,576,120	160,671,760	109,182,340	67,842,759
Apr 8	23.1	−1.39	259,512,270	161,253,440	109,866,470	68,267,860
18	37.8	−1.35	259,020,490	160,947,870	109,590,530	68,096,400
28	52.8	−1.22	257,041,060	159,717,910	108,368,120	67,336,825

Table 5. (Cont'd)

Date	Spacecraft celestial position		Spacecraft distance from earth		Spacecraft distance from sun	
	Longitude, deg	Latitude, deg	km	mi	km	mi
May 8	68.2	−1.00	253,461,030	157,493,380	106,262,500	66,028,458
18	84.3	−0.69	248,168,570	154,204,800	103,394,850	64,246,583
28	101.5	−0.30	240,989,400	149,743,870	99,957,921	62,110,972
Jun 5	116.1	0.05	233,738,570	145,238,410	96,983,594	60,262,810
15	135.8	0.51	222,639,670	138,341,880	93,293,817	57,970,089
25	156.9	0.94	209,164,010	129,968,490	90,055,070	55,957,625
Jul 5	179.5	1.13	193,332,690	120,131,360	87,747,055	54,523,491
15	202.8	1.39	175,506,580	109,054,730	86,771,518	53,917,321
25	226.4	1.29	156,391,280	97,177,034	87,315,136	54,255,109
Aug 4	249.2	0.98	136,890,840	85,060,026	89,272,527	55,471,376
14	270.8	0.55	117,945,890	73,288,179	92,290,766	57,346,220
24	290.9	0.08	100,298,380	62,322,523	95,898,906	59,588,817
Sep 3	309.4	−0.37	84,392,563	52,439,107	99,633,472	61,909,368
13	326.7	−0.75	70,500,300	43,806,855	103,108,810	64,068,845
23	342.9	−1.05	58,787,829	36,529,063	106,036,180	65,887,830
Oct 2	356.9	−1.24	50,241,330	31,218,514	108,035,560	67,130,183
12	11.9	−1.36	43,287,852	26,897,823	109,431,850	67,997,801
22	26.6	−1.39	39,522,366	24,558,059	109,889,930	68,282,434

Nov 1	41.4	−1.33	39,426,327	24,498,384	109,387,130	67,970,008
11	56.4	−1.18	43,123,027	26,795,406	107,948,410	67,076,030
21	71.9	−0.93	50,219,506	31,204,954	105,649,710	65,647,684
Dec 2	90.0	−0.57	61,354,898	38,124,166	102,292,900	63,561,863
12	107.6	−0.16	74,143,564	46,070,674	98,723,133	61,343,710
22	126.5	0.30	89,184,600	55,416,740	94,980,412	59,018,091
Jan 1, 1969	146.9	0.76	106,182,370	65,978,662	91,473,020	56,838,699
11	168.9	1.14	124,671,380	77,467,202	88,675,244	55,100,241
21	191.9	1.36	143,901,400	89,416,182	87,042,072	54,085,435
31	215.5	1.36	162,972,480	101,266,400	86,875,484	53,981,923
Feb 10	238.8	1.14	181,011,020	111,247,503	88,207,904	54,809,850
20	260.9	0.76	197,333,050	122,617,070	90,788,401	56,413,297
Mar 2	281.8	0.30	211,601,700	131,483,200	94,183,053	58,522,635
12	301.0	−0.17	223,762,870	139,039,800	97,912,430	60,839,962
22	318.9	−0.58	233,880,050	145,326,320	101,549,790	63,100,111
Apr 1, 1969	335.5	−0.92	242,101,980	150,435,190	104,761,310	65,095,659
11	351.3	−1.17	248,595,630	154,470,160	107,307,690	66,677,909
21	6.5	−1.32	253,463,750	157,495,070	109,030,150	67,748,195
May 1	21.3	−1.39	256,802,940	159,569,950	109,834,770	68,248,163
11	36.0	−1.36	258,693,360	160,744,600	109,681,060	68,152,653
21	50.9	−1.24	259,138,470	161,021,180	108,576,600	67,466,367
31	66.2	−1.03	258,128,280	160,393,480	106,578,010	66,224,505

Table 5. (Cont'd)

Date	Spacecraft celestial position		Spacecraft distance from earth		Spacecraft distance from sun	
	Longitude, deg	Latitude, deg	km	mi	km	mi
Jun 10	82.3	−0.73	255,625,390	158,838,250	103,798,440	64,497,362
20	99.3	−0.36	251,498,780	156,274,100	100,420,530	62,398,425
30	117.6	−0.08	245,588,320	152,601,510	96,712,709	60,094,490
Jul 10	137.3	0.55	237,717,000	147,710,490	93,040,005	57,812,378
20	158.6	0.97	227,685,570	141,477,250	89,852,996	55,832,062
30	181.2	1.28	215,440,610	133,868,590	87,630,112	54,450,826
Aug 9	204.6	1.[illegible]	201,205,170	125,023,100	86,761,937	53,911,367
19	228.1	1.27	185,486,230	115,255,800	87,415,226	54,317,302
29	250.9	0.95	169,053,360	105,044,880	89,463,655	55,590,137
Sep 8	272.3	0.52	152,741,470	94,909,146	92,540,942	57,502,275
18	292.3	0.04	137,185,660	85,243,21[illegible]	96,173,009	59,759,136
28	310.8	−0.40	122,781,590	76,292,943	99,900,400	62,075,230
Oct 8	327.9	−0.77	109,709,919	68,170,130	103,344,330	64,215,188
18	344.1	−1.07	97,923,473	60,846,824	106,222,960	66,003,885
28	359.5	−1.27	87,276,778	54,231,275	108,342,270	67,320,763
Nov 7	14.5	−1.37	77,603,785	48,220,756	109,580,060	68,089,892
17	29.2	−1.38	68,723,362	42,702,717	109,872,170	68,271,402
27	43.9	−1.31	60,593,735	37,651,201	109,204,210	67,856,348

Dec 7		59.1	−1.14	53,482,734	33,232,629	107,609,590	66,865,496
17		74.8	−0.88	48,140,211	29,912,940	105,174,020	65,352,105
27		91.3	−0.54	46,071,544	28,627,530	102,046,120	63,408,516
Jan 7	1970	110.8	−0.08	49,689,646	30,875,714	98,079,109	60,943,532
17		129.9	0.38	59,044,491	36,688,546	94,346,426	58,624,151
27		150.7	0.83	73,379,280	45,595,770	90,928,106	56,500,105
Feb 6		172.9	1.19	91,278,195	56,717,640	88,302,664	54,868,731
16		196.0	1.37	111,267,200	69,138,231	86,908,598	54,002,498
26		219.6	1.34	131,954,110	81,992,481	87,007,479	54,063,940
Mar 7		240.5	1.12	150,114,590	93,276,878	88,363,051	54,906,254
17		262.6	0.72	168,908,320	104,954,770	91,017,983	56,555,952
27		283.3	0.26	185,737,290	115,411,800	94,451,829	58,689,645
Apr 6		302.4	−0.20	200,379,510	124,510,060	98,186,596	61,010,321
16		320.1	−0.61	212,840,420	132,252,910	101,801,710	63,256,647
26		336.7	−0.94	223,275,580	138,737,010	104,970,580	65,225,694
May 6		352.5	−1.18	231,844,610	144,061,560	107,460,380	66,772,784
16		7.6	−1.33	238,707,230	148,325,790	109,117,590	67,802,528
26		22.4	−1.39	244,041,440	151,640,320	109,852,540	68,259,200
Jun 5		37.1	−1.36	247,964,450	154,077,970	109,628,370	68,119,908
15		52.0	−1.23	250,563,000	155,692,630	108,456,150	67,391,523
25		67.4	−1.01	251,921,170	156,536,560	106,396,340	66,111,618

Table 5. (Cont'd)

Date	Spacecraft celestial position		Spacecraft distance from earth		Spacecraft distance from sun	
	Longitude, deg	Latitude, deg	km	mi	km	mi
Jul 5	83.5	−0.71	252,039,830	156,610,290	103,566,650	64,353,334
15	100.6	−0.33	250,859,860	155,877,090	100,155,480	62,233,730
25	118.9	0.11	248,286,210	154,277,900	96,437,984	59,923,784
Aug 4	138.8	0.58	244,122,930	151,690,950	92,786,081	57,654,597
14	160.2	1.00	238,146,040	147,977,709	89,654,818	55,708,920
24	182.9	1.29	230,234,390	143,061,020	87,520,482	54,382,705
Sep 3	206.4	1.39	220,436,010	136,972,590	86,761,453	53,911,067
13	229.8	1.25	209,089,890	129,922,243	87,524,021	54,384,904
23	252.5	0.92	196,828,030	122,303,260	89,661,227	55,712,903
Oct 3	273.9	0.48	184,336,360	114,541,300	92,794,272	57,659,687
13	293.7	0.01	172,179,970	106,987,670	96,446,755	59,929,235
23	312.1	−0.43	160,745,440	99,882,585	100,163,740	62,238,862
Nov 2	329.2	−0.80	150,165,720	93,308,653	103,573,490	64,357,585
12	345.3	−1.08	140,371,690	87,222,923	106,401,100	66,114,580
22	0.7	−1.28	131,205,310	81,527,201	108,458,370	67,392,907
Dec 2	15.6	−1.38	122,407,570	76,060,539	109,627,770	68,119,535
12	30.3	−1.38	113,667,960	70,629,993	109,848,380	68,256,993
22	45.1	−1.30	104,727,740	65,074,799	109,111,130	67,798,513

Jan 1, 1971	60.2	−1.12	95,362,695	59,255,631	107,451,240	66,767,102
11	75.9	−0.86	85,470,045	53,108,623	104,959,190	65,218,619
21	92.6	−0.51	75,288,170	46,781,899	101,788,780	63,248,616
31	110.3	−0.09	65,635,443	40,783 973	98,173,141	61,001,961
Feb 10	129.5	0.37	58,451,682	36,320,191	94,439,185	58,681,788
20	150.2	0.82	56,999,673	35,417,955	91,007,738	56,549,586
Mar 2	172.3	1.18	63,766,661	39,622,765	88,356,765	54,902,348
12	195.5	1.37	77,857,100	48,378,158	86,927,303	54,014,121
22	219.0	1.35	96,259,080	59,812,618	86,986,982	54,051,204
Apr 1	242.2	1.10	116,164,400	72,181,208	88,524,199	55,006,386
11	264.2	0.69	135,706,940	84,324,381	91,253,044	56,702,012
21	284.7	0.23	153,807,820	95,571,745	94,724,950	58,859,354
May 1	303.8	−0.23	169,943,670	105,598,100	98,463,847	61,182,597
11	321.4	−0.64	184,002,150	114,333,630	102,055,590	63,414,405
21	337.9	−0.96	196,054,560	121,822,650	105,180,930	65,356,402
31	353.6	−1.20	206,239,490	128,151,280	107,613,560	66,867,962
Jun 10	8.7	−1.34	214,771,640	133,452,910	109,205,220	67,856,975
20	23.5	−1.39	221,851,870	137,852,360	109,870,530	68,270,382
30	38.2	−1.35	227,643,560	141,451,150	109,576,350	68,087,590
Jul 10	53.2	−1.22	232,329,480	144,362,840	108,337,330	67,317,696
20	68.6	−0.99	236,042,330	146,669,900	106,217,850	66,000,712
30	84.8	−0.68	238,842,410	148,409,790	103,340,330	64,212,701

Table 5. (Cont'd)

Date	Spacecraft celestial position		Spacecraft distance from earth		Spacecraft distance from sun	
	Longitude, deg	Latitude, deg	km	mi	km	mi
Aug 9	101.9	−0.29	240,764,580	149,604,170	99,898,944	62,074,325
19	120.4	0.15	241,741,900	150,211,450	96,175,593	59,760,743
29	140.4	0.62	241,585,650	150,114,360	92,548,931	57,507,239
Sep 8	161.9	1.02	240,071,860	149,173,740	89,477,920	55,599,001
18	184.6	1.31	236,970,190	147,246,440	87,435,827	54,330,103
28	208.1	1.39	232,162,070	144,258,820	86,787,958	53,927,536
Oct 8	231.5	1.24	225,822,810	140,319,790	87,659,827	54,469,103
18	254.1	0.90	218,379,940	135,695,000	89,882,981	55,850,694
28	275.4	0.45	210,351,440	130,706,330	93,067,874	57,829,694
Nov 7	295.1	−0.02	202,233,490	125,662,060	96,736,546	60,109,302
17	313.4	−0.46	194,353,130	120,765,430	100,439,300	62,410,085
27	330.4	−0.82	186,807,410	116,076,740	103,811,790	64,505,658
Dec 7	346.4	−1.10	179,559,050	111,572,820	106,586,160	66,229,570
17	1.7	−1.29	172,454,200	107,158,070	108,580,000	67,468,482
27	16.6	−1.38	165,225,010	102,666,060	109,680,380	68,152,228

Table 6. Science experiments

Experiment	Experimenter	Affiliation	On-board instrument
Trapped radiation	J. A. Van Allen	State University of Iowa	Trapped radiation detector
Solar plasma	H. S. Bridge	Massachusetts Institute of Technology	Plasma probe
Helium magnetometer	E. J. Smith	Jet Propulsion Laboratory	Helium magnetometer
Ultraviolet photometer	C. A. Barth	University of Colorado	Ultraviolet photometer
Dual frequency radio propagation	V. R. Eshleman	Stanford University	Dual frequency receiver
S-band radio occultation	A. J. Kliore	Jet Propulsion Laboratory	Radio frequency downlink performance data
Celestial mechanics	J. Anderson	Jet Propulsion Laboratory	None (tracking data)

Table 7. Unit reference designations of components

Subsystem	Unit	Ref. No.	Weight, lb
Antennas	High-gain antenna	2E1	4.91
	Low-gain antenna	2E2	3.41
	Dual frequency receiver		
	423-MHz antenna	15E3	0.52
	50-MHz antenna (+X)	15E2F1	0.21
	50-MHz antenna (+Y)	15E2F3	0.21
Attitude control	Control system electronics	7A1	8.00
	Control gyros and electronics	7A2	10.99
	Attitude control +X/−Y gas subsystem	7GA1/2	
	Gas vessel (dry)	7GV1	4.22
	Pressure regulator	7GR1	1.25
	4-jet gas manifold (+X)	7GM41	1.40
	2-jet gas manifold (−Y)	7GM21	0.83
	Attitude control −X/+Y gas subsystem	7GA1/2	
	Gas vessel (dry)	7GV11	4.22
	Pressure regulator	7GR11	1.25
	4-jet gas manifold (−X)	7GM411	1.40
	2-jet gas manifold (+Y)	7GM211	0.83
	Primary sun sensor (Bay II)	7PS2	0.17
	Primary sun sensor (Bay VI)	7PS6	0.13
	Secondary sun sensor (Bay II)	7SS2	0.13
	Secondary sun sensor (Bay VI)	7SS6	0.13
	Sun gate sensor	7SG7	0.13
	Earth sensor	7ED6	0.34
	Canopus sensor	7CS8	5.58
	Canopus sun shutter	7CS8/A	0.67
	Planet sensor	7LS8	0.57
	Terminator sensor	7TS2	0.16
Cabling	Electronic assembly 1		
	power harness	9W4	2.03
	pyro harness	9W18	1.39
	support hardware		0.43
	Bay II		
	PIPS pyro harness	9W10	0.85
	PIPS instrumentation harness	9W11	0.56
	Electronic assembly 3		
	science harness	9W20	2.57
	data automation subsystem interconnect	9W21	4.53

Table 7. (Cont'd)

Subsystem	Unit	Ref. No.	Weight, lb
Cabling (cont'd)	plasma probe interconnect	9W27	0.27
	magnetometer interconnect	9W30	0.86
	support hardware		0.43
	Electronic assembly 4		
	command harness	9W3	1.47
	data encoder harness	9W6	3.54
	support hardware		0.43
	Electronic assembly 5		
	radio harness	9W13	0.56
	tape recorder harness	9W17	1.37
	support hardware		0.43
	Electronic assembly 6		
	radio harness	9W2	1.30
	support hardware		0.42
	Electronic assembly 7		
	CC&S harness	9W5	2.33
	attitude control harness	9W7	0.93
	support hardware		0.43
	Upper ring harness	9W1	6.00
	Upper ring power harness	9W9	1.30
	Cable trough		1.00
	Solar panel pyro harness	9W8	1.12
	Solar panel squib harnesses (4)	9W38	0.89
	Attitude control gas system harness	9W15/16	1.82
	Lower ring signal harness	9W19	7.44
	Upper ring science signal harness	9W22	0.48
	Magnetometer signal harness	9W26	0.11
	Magnetometer coaxial cable (cell)	9W29	0.23
	Magnetometer coaxial cable (lamp)	9W34	0.24
	APAC squib harness	9W28	0.30
Central computer and sequencer	Central clock	5A1	1.32
	Launch counter	5A2	1.65
	End counter	5A3	1.78
	Maneuver clock	5A4	1.34
	Maneuver duration	5A5	1.46
	Address register and maneuver duration output	5A6	1.72
	Input decoder	5A7	1.14
	Central computer and sequencer transformer-rectifier	5A8	1.33
	Relay hold transformer–rectifier	5A9	0.49

Table 7. (Cont'd)

Subsystem	Unit	Ref. No.	Weight, lb
Command	Command detector 1	3A1	1.51
	Command detector 2	3A2	1.43
	Command detector 3	3A3	1.58
	Command program control	3A4	1.53
	Command decoder 1	3A5	1.46
	Command decoder 2	3A6	1.42
	Command decoder and power supply	3A7	1.44
Data automation subsystem	DAS power supply	20A1	3.56
	Logic	20A2–20A9	11.04
Data encoder	Pseudonoise generators	6A1	1.83
	Modulator, mixer, transfer register, data selector	6A2	1.87
	Analog-to-digital converter	6A3	1.63
	Analog-to-digital converter	6A4	1.66
	Event counters	6A5	1.92
	Functional switching	6A6	1.75
	Decks 100, 110	6A7	1.94
	Decks 210, 220	6A8	1.77
	Decks 200, 300	6A9	1.67
	Decks 400, 410	6A10	1.70
	Decks 420, 430	6A11	1.74
	Low-level amplifier	6A12	1.66
	Power supply	6A13	2.26
Mechanical devices	Cruise dampers and latches		0.22/panel
	High-gain antenna pointing angle change deployment mechanism		0.57
	Long low-gain antenna support damper		0.39
	Short low-gain antenna support damper		0.32
	Pyro arming switch	8AS1	0.1
	Separation initiated timer	8M1	0.6
	Solar panel boost dampers (8 required)		0.11 ea
	Solar panel deployment springs and open switches		0.32/panel

Table 7. (Cont'd)

Subsystem	Unit	Ref. No.	Weight, lb
Post-injection propulsion subsystem	Post-injection propulsion subsystem	10A	43.54
Power	Power regulator	4A8	21.22
	Power distribution subassembly	4A11	1.86
	Power synchronizer	4A12	1.64
	Battery charger assembly	4A13	2.94
	Battery assembly	4A14	33.13
	2400-Hz main inverter	4A15	2.60
	2400-Hz maneuver inverter	4A16	2.65
	400-Hz 3-phase inverter	4A18	3.36
Pyrotechnics	Pyrotechnics control assembly	8A1	4.02
	Pyrotechnics control assembly	8A2	4.01
Radio	Receiver assembly	2RA1	4.40
	Receiver assembly	2RA2	3.90
	Receiver transformer–rectifier	2TR1	0.88
	Exciter assembly	2RE1	5.04
	Attenuator	2AT1	0.20
	Directional coupler, high-gain antenna	2DC1	0.26
	Directional coupler, omni directional antenna	2DC2	0.49
	Auxiliary oscillator, temperature transducer	2TT1	0.03
	Dual 3-port circulator switch	2CS3	2.55
	5-port circulator switch	2CS2	2.24
	Cavity filter 2	2CF2	0.38
	Cavity power amplifier	2PA1	1.78
	Control circuits	2CC1	1.44
	Cavity power supply	2PS2	2.07
	Traveling wave tube amplifier power supply	2PS3	3.45
	Traveling wave tube amplifier	2PA2	1.59
	Exciters, transformer–rectifier	2TR2	1.06

Table 7. (Cont'd)

Subsystem	Unit	Ref. No.	Weight, lb
Science instruments	Dual frequency receiver	35A1/2	2.55 ea
	Trapped radiation detector	25A1	2.63
	Plasma probe sensor	32A1	1.22
	Plasma probe electronics	32A2	1.76
	Plasma probe electronics	32A3	1.29
	Plasma probe electronics	32A4	2.61
	Magnetometer electronics transformer–rectifier	33A2	2.69
	Magnetometer electronics	33A3	2.38
	Magnetometer sensor	33A1	1.31
	UV photometer	34A1	7.61
	UV photometer electronics	34A2	1.60
Solar panels	Solar panel +X	4A1	15.11
	Solar panel −X	4A5	15.44
	Solar panel +Y	4A3	15.25
	Solar panel −Y	4A7	15.23
Structure	Bay II shear web		1.63
	Electronic assembly chassis		
	Bay I		4.22
	Bay III		4.62
	Bay IV		4.30
	Bay V		4.55
	Bay VI		4.30
	Bay VII		4.34
	Octagon structure		34.50
	Propulsion support structure		2.25
	Superstructure		3.25
Tape recorder	Tape transport	16A1	9.07
	Tape electronics 1	16A2	2.06
	Tape electronics 2	16A3	1.89
	Tape electronics 3	16A4	2.36
	Tape electronics 4	16A5	1.96
	Tape electronics 5 (TR)	16A6	1.74
Temperature control reference	+X S-13 white	11TT61	0.11
	−Y Cat-a-Lac black	11TT67	0.11
	−X S-13M white	11TT65	0.11

Table 7. (Cont'd)

Subsystem	Unit	Ref. No.	Weight, lb
Temperature control	Cable trough blanket		0.45
	Louvers (6 sets)		1.35 ea
	Lower thermal blanket and attach hardware		2.19
	Side shields		1.68
	Upper thermal blanket and attach hardware		1.83
	Deployable sun shade and attach hardware		0.78
	Trapped radiation detector shields		0.07
	Magnetometer thermal shield		0.04
	Attitude control gas jet shields (4 required)		0.08 ea

Table 8. Electrical components

Subsystem	Capacitors	Diodes	Resistors	Transistors	Other[a]	Total
Radio (02)	594	203	658	122	197	1774
Command (03)	406	791	1030	338	50	2615
Power (04)	145	293	395	134	97	1064
CC&S (05)	257	728	1059	266	260	2570
Data encoder (06)	1465	1464	3416	1055	185	7585
Attitude control (07)	227	291	523	119	101	1261
Pyrotechnic (08)	42	48	114	4	32	240
Cabling (09)						
Temperature control (11)					3	3
Mechanical devices (12)	6	4	6		13	29
Tape recorder (16)	232	331	686	197	33	1479
Data automation subsystem (20)	144	89	261	62	617[b]	1173
Trapped radiation detector (25)	94	38	206	61	18	417
Plasma probe (32)	162	425	684	211	12	1494
Helium magnetometer (33)	212	83	597	153	6	1051

Ultraviolet photometer (34)	203	148	665	155	52	1223
Dual frequency receiver (35)	405	111	481	150	143[b]	1290
Total subsystem parts	4594	5047	10781	3027	1819	25268

NOTE: This table does not include 518 connectors.

[a]"Other" includes inductors, relays, transformers, integrated circuits, cores, silicon-controlled rectifiers and switches, crystals, thermistors, sensitors, fuses and tubes.

[b]There are 566 integrated circuits included in the total for the data automation subsystem and 28 integrated circuits in the dual frequency receiver. Each integrated circuit is equivalent to an average of 33.5 conventional components.

Subsystem	Structure	Experiments*	Bay I	Bay II	Bay III	Bay IV	Bay V	Bay VI	Bay VII	Bay VIII
Structure 01	38.70		4.62		5.01	4.70	4.96	4.78	4.59	
Antennas 02										
Radio 02							11.38	26.76		
Command 03						10.37				
Power 04			15.42							21.22
Solar panels 04										
CC&S 05									12.23	
Data encoder 06						23.40				
Guid & contr 07	.07			3.26					18.99	
Pyrotechnic 08			8.03							
Wiring 09			3.42	1.41	7.48	5.02	1.93	1.30	3.26	
Propulsion 10	2.33			43.54						
Temp contr 11		.12	.03	.28	.03	.06	.09	.09	.03	.03
Mech dev 12										
Tape recorder 16							19.35			
Science (total)	0	15.44	0	0	32.03	0	0	0	0	0
DFR ant 15		.94								
DAS 20					14.60					
TRD 25		2.63								
Bracket† 26										
Plas probe 32		1.22			5.66					
Magnetom 33		1.31			5.07					
UV photom 34		7.61			1.60					
DFR 35		1.73			5.10					
Launched weight	41.10	15.56	31.52	48.49	44.55	43.55	37.71	32.93	39.10	21.25

* Independently mounted.

** Actuators and mechanisms.

† Ion chamber bracket.

A/C = attitude control.

TC = thermal control.

Table 9. Mariner V launched weight, lb.

Battery	Solar panels	A/C gas systems	A/C sensors ✻	Antennas	TC assemblies	Pyro squibs	Act and Mech. ✻✻	Cabling	Launched weight
								.98	68.34
				8.33					8.33
				1.04					39.18
									10.37
33.13									69.77
	61.11								61.11
									12.23
									23.40
		26.68	7.98						56.98
						.25	.25		8.53
	1.12	1.82						16.87	43.63
									45.87
.03	.36	.06	.06	.06	15.92				17.25
							5.46		5.46
									19.35
0	0	0	0	.57	0	0	0	1.33	49.37
									.94
									14.60
									2.63
				.24					.24
									6.88
				.33				1.33	8.04
									9.21
									6.83
33.16	62.59	28.56	8.04	10.00	15.92	.25	5.71	19.18	539.17

Bay I: power.

Bay II: propulsion.

Bay III: science and DAS.

Bay IV: data encoder and command.

Bay V: RF communications and tape recorder.

Bay VI: RF communications.

Bay VII: attitude control and CC&S.

Bay VIII: power regulator.

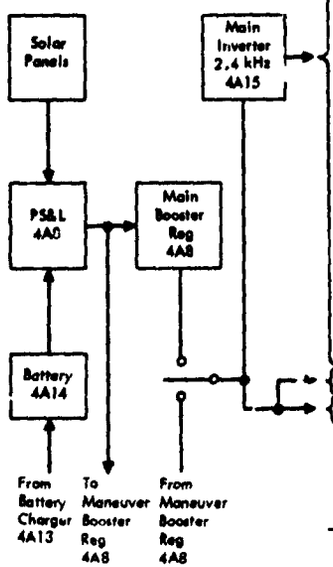
Table 10. Redundant equipment backup sources

Redundant equipment	Type of redundancy employed	Discussion
RF exciters	Block	Two identical exciters switchable either by internal logic or by ground command. Only one operates at any time.
Pyrotechnic control assemblies	Block	Two identical half systems, both on line continuously after separation.
Midcourse propulsion valves	Block	Duplicate pyrotechnic-actuated valves provide the capability for two midcourse maneuvers.
Power booster regulators	Block	Failure sensing circuit detects over/under voltage condition at main booster output. Switches maneuver booster on and main booster off.
Science power relays	Block	Three relays can supply power to the science loads. One operated at separation or DC-V2; one operated at DC-V2 or MT-7; one operated at DC-V25, overriding science inhibit logic.
Analog-to-digital converter and pseudonoise code generator	Block	Two identical units switchable by ground command. Only one operates at any time.
Attitude control gas system	Block	Two half systems and pressure vessels. Both operate continuously after attitude control turn-on.
DAS encounter clocks	Block	Two clocks count in parallel to achieve recording sequence control. Clocks A and B initiated by DC-V16 and planet sensor, respectively.
DAS oscillators	Block	Two crystal oscillators are on continuously. Failure of prime oscillator causes backup to be gated into countdown circuit to obtain required internal frequencies.

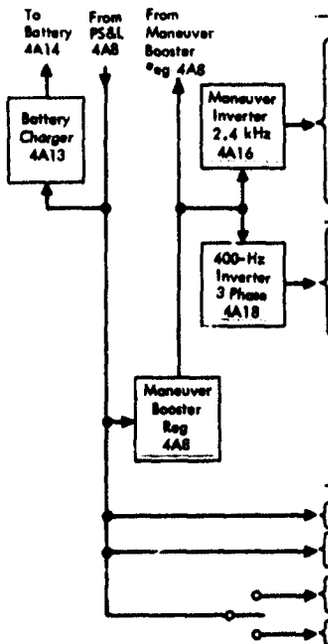
Table 10. (Cont'd)

Redundant equipment	Type of redundancy employed	Discussion
RF power amplifiers	Functional	Cavity and TWT power amplifiers plus associated power supplies switchable either by internal logic or by ground command. Only one operates at any time.
Pyrotechnic arming devices	Functional	Two separation-activated switches: pyrotechnic arming switch and separation initiated timer. Either one can power both pyrotechnic half systems.
Power frequency sources	Functional	Primary control is a 38.4-kHz synchronization signal from the CC&S. In the absence of this signal, synchronization is derived from an oscillator internal to power, or the inverters will free-run at approximately 2.4 kHz.
Roll attitude sensors	Functional/ alternate mode	A Canopus sensor and an earth sensor are used. The latter is useful only during the first 3 weeks of the mission. Accuracy of roll attitude determination is somewhat reduced.
Roll orientation controls	Alternate mode	Normally initiated at L-3 or DC-V13. Canopus sensor on with brightness gate in effect. This mode may be restored after use of an alternate by DC-V19. DC-V15. Canopus sensor on; brightness gate removed from circuit. Canopus sensor will track any detectable light source. Gyros disabled. DC-V18. Inertial roll control. Canopus sensor off, gyros on. Pitch and yaw gyros in rate mode; sun sensors unaffected. DC-V20. No roll control. Canopus sensor off; gyros off.

Table 11. Average power loads



System / subsystem	Ref. No.	Normal flight sequence phases, W						Abnormal flight sequence phases (gyros on), W		
		Launch	Pre-sun acquis	Cruise	Maneuver	Encounter	Play-back	Cruise	Encounter	Play-back
DAS	20A1	---	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0
Dual frequency receiver	35	---	1.83	1.83	1.83	1.83	1.83	1.83	1.83	1.83
Trapped radiation detector	25A1	---	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Plasma probe	32A4	---	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6
UV photometer	34	---	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6
Magnetometer	33A2	---	7.21	7.21	7.21	7.21	7.21	7.21	7.21	7.21
Total science, 2.4 kHz		---	27.74	27.74	27.74	27.74	27.74	27.74	27.74	27.74
Data encoder	6A13	8.33	7.84	7.84	7.84	7.84	7.84	7.84	7.84	7.84
Tape electronics	16A4	---	---	---	---	7.1	6.4	---	7.1	6.4
Command	3A7	2.09	2.09	2.09	2.09	2.09	2.09	2.09	2.09	2.09
CC&S T/R	5A8	4.84	4.84	4.84	4.84	4.84	4.84	4.84	4.84	4.84
Control system electronics	7A1	13.6	13.6	5.5	17.8 [a]	5.5	5.5	14.0	14.0	14.0
Pyrotechnic control sub	8A1	---	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48
Pyrotechnic control sub	8A2	---	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48
Power sync	4A12	3.79	3.79	3.79	3.79	3.79	3.79	3.79	3.79	3.79
Receiver	2TR1	7.8 [b]	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8
Control unit	2CC1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Exciter	2TR2	11.2 [c]	11.2	11.2	11.2	11.2	11.2	11.2	11.2	11.2
Power distribution	4A11	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85
Total engineering, 2.4 kHz		54.5	54.97	46.87	59.17	53.97	53.27	55.37	62.47	61.77
Total from main inverter	4A15	54.5	82.71	74.61	86.91	81.71	81.01	83.11	90.21	89.51
Total into main inverter	4A15	66.5	96.2	87.8	101.1	95.6	94.7	96.6	104.7	103.8
Telemetry oscillator	4A8	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6
Power sync	4A12	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69
Total from main booster regulator	4A8	70.8	100.5	92.1	105.4	99.9	99.0	100.9	109.0	108.1
Total into main booster regulator	4A8	87.4	121.1	114.6	126.4	123.8	122.7	124.7	130.5	133.5



Relay hold	5A9	7.50	---	---	---	---	---	---	---	---	---
Control system electronics	7A1	---	---	---	7.0	---	---	---	---	---	---
Gyro control electronics	7A2	8.5	8.5	---	8.5	---	---	9.5	9.5	9.5	
Total from maneuver inverter	4A16	16.0	8.5	---	15.5	---	---	9.5	9.5	9.5	
Total into maneuver inverter	4A16	23.5	14.8	---	23.0	---	---	16.1	16.1	16.1	
Gyro motors	7A2	9.6	9.6	---	9.6	---	---	9.6	9.6	9.6	
Tape recorder	16A5	3.41	3.41[d]	---	0.2	---	---	0.2	0.2	0.2	
Total from 400-Hz, 3ϕ inverter	4A18	13.01	13.01	---	9.8	---	---	9.8	9.8	9.8	
Total into 400-Hz, 3ϕ inverter	4A18	16.06	15.87	---	12.55	---	---	12.55	12.55	12.55	
Total from maneuver booster	4A8	39.56	30.67	---	35.55	---	---	28.65	28.65	28.65	
Total into maneuver booster	4A8	53.46	42.95	---	48.70	---	---	44.77	44.77	44.77	
Battery charger	4A13	4.4	4.4	13.1[e]	1.4[f]	0.0	0.0	13.1[e]	0.0	0.0	
Heater power magnetometer	33A2	0.6	0.6	2.7[g]	2.7	1.7	1.7	2.7[g]	1.7	1.7	
Cavity amplifier power supply	2PS2	10.2	32.6	32.6	32.6	32.6	32.6	32.6	32.6	32.6	
TWT power supply	2PS3	0.0	61.2	61.2	61.2	61.2	61.2	61.2	61.2	61.2	
Total from PS&L (cavity)		156.1	201.7	163.0	211.8	158.1	157.0	217.87	209.6	212.6	
Total from PS&L (TWT)		145.9	230.3	191.6	240.4	186.7	185.6	246.5	238.2	216.9	
Total demand on solar panels or battery (cavity)		160.9	208.1	166.3	216.1	161.3	160.2	222.3	213.9	241.2	
Total demand on solar panels or battery (TWT)		150.4	237.4	195.5	245.3	190.5	189.4	251.5	243.1	246.1	

Table 11. (Cont'd)

Acquis = acquisition
Reg = regulator
T/R = transformer-rectifier

[a] 22.8 W with gas jets operating.

[b] Add 0.7 W for ranging on.

[c] Exciter A 11.2 W, exciter B 10.4 W.

[d] Turned off 1 min after separation

[e] Charger on 13.1 W, with 46.9-V input and battery at 29.1-V charger off 0 watts.

[f] 13.1 W if power source is solar panels, 4.4 W if on battery.

[g] 3.3 W at 48 V near earth.

Spacecraft voltages were as follows:

	Expected voltage range, V	Voltage used in calculations, V
Launch	33-28	28
Preacquisition	28-48	28
Cruise	48-41	41
Maneuver	48-28	28
Encounter	41	41
Playback	41-39	41

Table 12. Temperature control reference information

Reference designation	Location on spacecraft	Telemetry channel	Coating	Telemetry temperature range, °F	α/ε at launch	α/ε at last reading	Time off scale from launch, days
11TT61	+X panel	412	S-13 white	−30 to +8	0.23	0.48	48
11TT67	−Y panel	413	Cat-a-Lac black	134 to 248	1.10	1.06	135
11TT65	+X panel	432	S-13 M white	−58 to +13	0.23	0.38	39

α = solar absorptance.

ε = emittance.

Table 13. Cabling subsystem engineering information

Unit designation	Connectors				Splices	Shields
	Circular	Rectangular	Other	Total		
9W1	23	1	1	25	43	10
9W2	4	9	1	14	8	18
9W3	3	7		10	1	4
9W4	5	11	1	17	25	20
9W5	5	14		19	4	5
9W6	6	18	1	25	37	23
9W7	2	6	1	9	0	5
9W8	5			5	0	4
9W9	10	1		11	8	15
9W10	11			11	0	10
9W11	5			5	0	0
9W13	3	3	1	7	6	8
9W15/16	8			8	8	0
9W17	4	8		12	5	14
9W18	5			5	0	32
9W19	15	2	12	29	39	27
9W20	6	12	1	19	0	9
9W21		27		27	82	0
9W22	1	3		4	1	1
9W26	1	4		5	0	6
9W27		3		3	0	4
9W28	3			3	0	2
9W29			2	2	0	1
9W30		2		2	0	0
9W34			2	2	0	0
9W38	12			12	0	8
Total	137	131	23	291	267	226

Table 14. Types of environmental tests

a. Major tests

System level	Subsystem level
	Bench handling
	Transportation vibration
	Humidity
Vibration	Explosive atmosphere
Shock	Shock
Acoustic	Static acceleration
Thermal-vacuum	Low-frequency vibration
Electromagnetic interference	Complex wave vibration
	Thermal-vacuum
	Thermal shock
	RF interference
	Magnetics

b. Miscellaneous tests

Type	Description
Structural test model	Basic structure static test
	Vibration
	Modal survey
	Acoustic
	Special electromagnetic interference test (squib safety)
	Solar panel deployment
Temperature control model	Space simulator thermal-vacuum
	Stray light reflectance
Developmental test model	Antenna pattern
	Preliminary stray light test
Other tests	RF noise measurements of AFETR operations
	Electronic packaging development
	Preliminary match-mate
	Thermal blanket ballooning
	Low-gain antenna extreme temperature
	Electronic assembly shipping container
	Solar panel structural development
	Antenna deployment testing
	Sun shade deployment testing

Table 15. Assembly level environmental test requirements

Test	TA test level		FA test level
Bench handling	Free-fall corner drop		Not applicable
Drop test	Height variable to weight		↓
Transportation vibration	1.3 g peak, 2–35 Hz 3.0 g peak, 35–48 Hz 5.0 g peak, 48–500 Hz		
Explosive atmosphere	Fuel and air during assembly operation		
Humidity	75% humidity and varied temperature		
Shock	Five 200-g, 0.7 ±0.2 ms TPST pulses, 3 axes		
Static acceleration	±14 g, 3 axes	5 min	↓
Vibration	±1.5 in., 1–[illegible] Hz	3 min	Not applicable
Sinusoidal (all assemblies)	3g peak, 4.4–15 Hz		↓
Sinusoidal (assemblies ≥10 lb	2.0 g rms sine, 15–40 Hz[a] 9.0 g rms sine, 40–250 Hz[b] 4.5 g rms sine, 250–2000 Hz	600 s	
Random noise	16.4 g rms noise, shaped spectrum	180 s	9.7 g rms noise, shaped spectrum, 60 s
Vacuum/temperature	−10°C (+14°F) +75°C (+167°F)	4 h 12 days	0°C (32°F), 2 h 55°C (131°F), 40 h
	10^{-4} torr		10^{-4} torr
Thermal shock (for external assemblies)	+75° to −46°C (167° to −50°F)		Not applicable

[a]Same for assemblies <10 lb.

[b]9.0 g rms sine, 40–2000 Hz for assemblies <10 lb.

Table 16. System level environmental test requirements

Test	Spacecraft 67-1 (backup)	Spacecraft 67-2 (flight)
Space simulator		
Part I: (systems validation)—launch through encounter & playback	212 h at 10^{-5} torr (or less)	212 h at 10^{-5} torr (or less)
Part II: (temperature control verification)	32 h at 100–290 W simulated solar intensity	32 h at 112–290 W simulated solar intensity
Vibration: sinusoidal	Roll axis 20–200–20 Hz, 1.0 **g** rms 3-1/3 min 2 lateral axes 20–200–20 Hz, 0.5 **g** rms 3-1/3 min per axis	Roll axis 20–200–20 Hz, 1.0 **g** rms 3-1/3 min 2 lateral axes 20–200–20 Hz, 0.5 **g** rms 3-1/3 min per axis
Vibration: random noise	Roll axis and 2 lateral axes Shaped noise spectrum, 10.7 **g** rms	Roll axis and 2 lateral axes Shaped noise spectrum, 9.7 **g** rms
Shock	Shroud V-band release firing Spacecraft V-band release firing All spacecraft pyrotechnics fired	Shroud V-band release firing All spacecraft pyrotechnics fired, except PIPS
Electromagnetic interference—RF susceptibility	Launch complex RF Agena telemetry RF C-band beacon DFR transmitter	Launch complex RF Agena telemetry RF C-band beacon DFR transmitter
Electromagnetic interference	DFR/S-band compatibility DFR/spacecraft compatibility	DFR/S-band compatibility DFR/spacecraft compatibility

Table 17. Subsystem environmental test summary (vibration and thermal-vacuum)

Environment	Total items in test	Total failures	Failure rate, %
TA tests			
Vibration	21	4	19
Vacuum/temperature	22	7	32
FA tests			
Vacuum/temperature	81	5	6.2
Vibration	117	7	6.5

Table 18. System level environmental test summary

Problem	Spacecraft 67-1 (backup)	Spacecraft 67-2 (flight)
Failure that should have been detected at subsystem level	2	0
Failure that could be detected only at systems level	4	1

Table 19. Spacecraft tests

At JPL	At AFETR
Subsystem tests	System tests
Subsystem interface tests	Spacecraft/Agena adapter matchmate
System tests	Electrical test
Attitude control quantitative leak test	RF loop calibration
Electrical modal survey	Dummy run countdown
Space simulator test	Umbilical release test
Vibration test	Weight and center-of-gravity measurement
Weight and center-of-gravity measurement	Cooling test

Table 19. (Cont'd)

At JPL	At AFETR
Free mode test	Joint flight-acceptance composite tests
Magnetic mapping	Science instrument calibrations
Agena/spacecraft interface test	Magnetic mapping
Launch countdown dummy run	Spacecraft /Agena matchmate
Space Flight Operations/ spacecraft/Deep Space Network compatibility test	Final system test
	Final electrical tests
	Spacecraft post-matchmate checkout
Current loop test	
System tests	Simulated launch

Table 20. Launch environmental telemetry channel assignment

Channel	Measurement	Calibration range (nominal)
	Launch spacecraft – Agena telemetry	
12	Spacecraft V-band strain gage 1	0–2700 lb
13	Spacecraft V-band strain gage 2	0–2700 lb
15 (44)	Shroud separation monitor	0–28 V
16 (17)	Shroud pressure	0–15 psia
16 (18)	Spacecraft–Agena temperature	0–165°F
17	Spacecraft axial vibration	±20 g
18	Adapter axial vibration	±30 g
F	JPL base band	—
	Launch complex environmental acoustic instrumentation	
1	Umbilical boom microphone 1	150 dB
2	Umbilical boom microphone 2	150 dB
3	Umbilical boom microphone 3	150 dB
4	Umbilical boom microphone 4	150 dB

Table 21. Mariner V telemetry channel assignment

Channel	Measurement	EU	Linear (L) or Nonlinear (N)	DN = 0	DN = 32	DN = 64	DN = 96	DN = 126
100	Deck sync	–	–	Deck sync has a DN value of 127 (binary: 1111111).				
101	Deck 20X	–	–	Channels 200–209 and 300–309 are subcommutated into chan. 101.				
102	Deck 21X	–	–	Channels 210–219 and 400–439 are subcommutated into chan. 102.				
103A	Pitch gyro	mrad/s	L	18.62	9.28	−0.02	−9.28	−17.93
103B	Pitch sun sensor	mrad	N	25.33	8.37	0.03	−8.27	−23.40
104A	Yaw gyro	mrad/s	L	19.35	9.68	0.00	−9.67	−18.75
104B	Yaw sun sensor	mrad/s	N	28.05	9.09	0.04	9.03	−25.45
105	Command detector monitor	$\Delta 2f_s$(Hz)	L	In lock: DN 0–31. Out of lock: DN 32–63.				
106	Receiver SPE	Hz	L	682.88	362.34	46.82	−268.13	−566.85
107	Roll gyro	mrad/s	L	17.17	8.52	−0.01	−8.49	−16.49
108	Canopus intensity	V	L	0.00	0.75	1.50	2.24	2.95
109	PS&L output voltage	V	L	23.85	31.64	39.14	46.68	54.09
110	Deck 22X	–	–	Channels 220–229 are subcommutated into chan. 110.				
111	Receiver AGC (coarse)	dBm	N	−102.23	−127.84	−142.28	−150.89	−150.74
112	Pitch position (coarse)	mrad	N	—	261.80	0	−261.80	—

113	Yaw position (coarse)	mrad	N	—	261.80	0	−261.80	—
114	Roll position and search	mrad	L	27.76	10.27	−1.25	−13.92	−27.01
115	Event registers 1 and 2	—	—	Each event counter consists of a 3-bit register.				
116	Event registers 3 and 4	—	—	Each event counter consists of a 3-bit register.				
117	Thrust chamber pressure	psia	L	14.59	89.42	164.23	239.02	309.10
118	Earth sensor	10^{-3}ft/cd	L	0.75	4.11	7.57	11.15	14.59
119	Propellant tank pressure	psia	L	14.51	139.24	263.92	388.56	505.36
200	Deck sync	—	—	Deck sync has a DN value of 127 (binary 1111111).				
201	Low deck position ADC/PNG ID	—	—	ADC/PNG A: DN 0–31. ADC/PNG B: DN 32–63.				
202	Deck 30X	—	—	Channels 300–309 are subcommutated into chan. 202.				
203	Dual input booster regulator current	A	L	−0.11	2.38	4.87	7.37	9.71
204	Communications converter input current	A	L	−0.07	1.17	2.42	3.67	4.84
205	Main booster regulator output current	A	L	−0.20	1.17	2.42	3.55	4.50
206	Battery voltage	V	L	23.16	27.68	32.06	36.29	40.12
207	2.4-kHz inverter output voltage	V	L	35.38	41.40	47.25	52.95	58.15

Table 21. (Cont'd)

Channel	Measurement	EU	Linear (L) or Nonlinear (N)	DN = 0	DN = 32	DN = 64	DN = 96	DN = 126
208	Attitude control +X/−Y gas pressure	psia	L	8.69	1024.47	2012.06	3029.78	4063.13
209	Attitude control −X/+Y gas pressure	psia	L	−5.57	1028.07	2003.14	3004.70	4043.35
210	Receiver LO drive	dBm	N	−8.71	−4.53	−1.38	1.07	2.71
211	Deck 40X/41X	--	-	Channels 400–419 are subcommutated into chan. 211.				
212	Deck 42X/43X	-	-	Channels 420–439 are subcommutated into chan. 212.				
213	High-gain antenna power (cavity)	dBm	N	17.66	31.44	36.49	39.54	41.23
214	Low-gain antenna power (cavity)	dBm	N	21.18	32.45	37.36	44.15	96.38
215	Receiver AGC (fine)	dBm	N	−128.23	−134.70	−140.21	−144.66	−147.78
216	Battery charger current	A	L	−0.02	0.24	0.49	0.74	0.97
217	Propellant temperature	°F	L	23.70	54.25	85.48	117.38	147.90
218	Attitude control +X/−Y gas temperature	°F	L	23.95	54.45	85.65	117.55	148.09

219	Attitude control −X/+Y gas temperature	°F	L	23.55	53.78	84.74	116.44	146.83
220	CC&S event timing	–	–	1 Count = 0.42 s.				
221	Maneuver booster regulator output current	A	L	−0.08	1.16	2.39	3.62	4.76
222	Solar panel 4A1 current	A	L	−0.09	1.16	2.41	3.65	4.82
223	Solar panel 4A5 current	A	L	−0.09	1.17	2.43	3.69	4.87
224	Solar panel 4A3 current	A	L	−0.09	1.16	2.40	3.65	4.81
225	Solar panel 4A7 current	A	L	−0.08	1.17	2.42	3.67	4.85
226	Battery current drain	A	L	−0.14	2.36	4.87	7.39	9.75
227	2.4-kHz inverter output current	A	L	0.10	0.81	1.49	2.12	2.68
228	Propulsion N_2 pressure	psia	L	12.95	1011.22	2008.23	3005.70	3942.78
229	Exciter RF power output	dBm	N	3.69	24.95	41.29	453.37	2946.66
300A	Cavity cathode current	mA	L	−0.03	20.76	41.55	62.35	81.84
300B	Helix current (TWT)	mA	L	−0.01	4.96	9.93	14.90	19.56
301	Exciter −25 V monitor	V	L	−27.55	−13.81	−0.06	13.69	26.58
302A	Exciter −15 V monitor (EXA-VCO)	V	L	−18.82	−9.43	−0.04	9.35	18.14

Table 21. (Cont'd)

Channel	Measurement	EU	Linear (L) or Nonlinear (N)	DN = 0	DN = 32	DN = 64	DN = 96	DN = 126
302B	Exciter −15 V monitor (EXB-VCO)	V	L	−24.47	−12.26	−0.05	12.16	23.60
303	Canopus cone angle	deg	L	Preset = DN 9 MT-1 = DN 26 MT-2 = DN 43 MT-3 = DN 60 MT-4 (option 2) = DN 77 Options 1 and 3 = DN 94				
304	Tape recorder pressure	psia	L	−0.01	9.96	19.94	29.91	39.26
305	Oxidizer pressure	psia	L	0	125.30	249.11	373.78	493.83
306	Terminator sensor excitation	–	–	DN = 0 before APAC. Approximately DN 107 after APAC.				
307	Spare channel							
308	Spare channel							
309	CC&S 28-V monitor	V	L	−0.02	14.37	28.75	43.13	56.62
400	Deck sync	–	–	Deck sync has a DN value of 127 (binary: 1111111).				
401	Bay I temperature	°F	L	23.41	54.05	85.32	117.23	147.72
402	Bay III temperature	°F	L	22.84	53.31	84.42	116.16	146.48
403	Solar panel 4A5 I_{SC}–V_{OC} temperature	°F	L	27.50	91.32	162.72	243.36	328.81

404	Bay V temperature	°F	L	22.97	53.45	84.62	116.46	146.92
405	Bay VI temperature	°F	L	22.59	53.13	84.33	116.17	146.61
406	+X roll and yaw jet assembly temperature	°F	L	−74.27	−25.29	28.23	87.00	147.47
407	Power regulator assembly temperature	°F	L	24.07	59.78	96.90	135.41	172.78
408	Propulsion N_2 tank temperature	°F	L	24.04	54.77	86.09	117.99	148.42
409	Solar panel 4A1 substrate temperature	°F	L	30.76	95.01	166.87	248.07	334.20
410	Canopus sensor temperature	°F	L	−50.62	−4.82	44.49	97.29	149.98
411	Spare channel							
412	TCR (S-13 white)	°F	L	−30.41	−10.57	9.27	29.12	47.73
413	TCR (Cat-a-Lac black)	°F	L	133 78	162.36	191.20	220.29	247.81
414	Auxiliary oscillator No. 1 temperature	°F	L	23.12	54.17	85.72	117.78	148.31
415	Standard cell current (I_{SC})	mA	L	0.86	34.84	69.96	105.13	138.16
416	Radiation resistance cell current (I_{SCR})	mA	L	0.74	34.72	69.85	105.04	138.07
417	Standard cell voltage (V_{OC})	mV	L	3.48	161.04	323.88	486.91	639.92

Table 21. (Cont'd)

Channel	Measurement	EU	Linear (L) or Nonlinear (N)	DN = 0	DN = 32	DN = 64	DN = 96	DN = 126
418	Auxiliary oscillator No. 2 temperature	°F	L	23.66	54.62	86.22	118.44	149.21
419	High-gain antenna	°F	N	−290.78	−235.37	−162.13	−54.90	90.88
420	Temperature reference	–	–	Nominal value: DN = 64				
421	Bay II temperature	°F	L	23.51	54.25	85.55	117.40	147.76
422	Plasma probe temperature	°F	L	−0.10	61.84	133.32	214.34	298.96
423	Bay IV temperature	°F	L	22.64	53.21	84.37	116.13	146.44
424	VCO temperature	°F	L	24.63	55.33	86.62	118.50	148.92
425	−Y pitch jet assembly temperature	°F	L	−75.11	−26.28	26.95	85.64	146.59
426	Bay VII temperature	°F	L	23.12	53.57	84.69	116.48	146.89
427	Solar panel 4A5 spar/zener temperature	°F	L	28.97	92.99	164.63	245.60	331.49
428	Battery temperature (No. 35)	°F	L	23.93	54.56	85.80	117.65	148.06
429	Solar panel 4A5 substrate temperature	°F	L	30.38	94.39	166.22	247.38	333.24

430	Primary sun sensor	°F	L	−0.82	48.68	101.96	159.74	218.62
431	Omnidirectional antenna mast temperature	°F	N	−289.96	−234.40	−162.07	−56.03	89.07
432	TCR (S-13M white)	°F	L	−58.22	−40.29	−22.27	−4.16	12.89
433	−X roll and yaw jet assembly temperature	°F	L	−74.18	−25.37	28.07	86.76	147.14
434	Upper thermal shield temperature	°F	N	−289.49	−233.95	−161.90	−56.35	88.12
435	Lower thermal shield temperature	°F	L	−1.51	47.92	101.55	159.38	217.41
436	Recorder temperature	°F	L	23.45	53.48	84.35	116.06	146.56
437	UV photometer temperature	°F	N	2.76	43.30	79.95	112.70	139.87
438	TRD temperature	°F	L	24.04	54.60	85.81	117.66	148.10
439	Magnetometer temperature	°F	L	−74.36	−25.81	27.98	87.04	147.18

Table 22. Time between telemetry samples

Rate, bps		Data mode 1, Channel No.				Data mode 2, Channel No.			
		100 - 119	200 - 229	300 - 309	400 - 439	100 - 119	200 - 229	300 - 309	400 - 439
8-1/3	s	16.8	168	1680	3360	50.4	504	5040	10080
	min	0.280	2.80	28.0	56.0	0.842	8.42	84.2	168
33-1/3	s	4.20	42.0	420	840	12.6	126	1260	2520
	min	0.070	0.700	7.00	14.0	0.210	2.10	21.0	42.0

Table 23. List of commands

Command number	Command name	Command address	
		Binary	Octal
DC-V1	Command TLM mode 1	110 000 011 00	6 030
DC-V2	Command TLM mode 2, turn on science	110 011 011 10	6 332
DC-V3	Track change command	110 101 011 00	6 530
DC-V4	Command TLM mode 4	110 011 101 00	6 350
DC-V5	Command switch data rate	110 000 10· 00	6 050
DC-V6	Command switch ADC/PNG	110 000 11· 00	6 060
DC-V7	Switch power amplifier	110 001 001 00	6 110
DC-V8	Switch exciters	110 110 101 10	6 652
DC-V9	Switch ranging	110 110 011 10	6 632
DC-V10	Transmit high–receive low	110 110 000 00	6 600
DC-V11	Transmit high–receive high	110 101 110 00	6 560
DC-V12	Transmit low–receive low	110 101 101 00	6 550
DC-V13	Maneuver command inhibit inhibit prop command (turn on Canopus sensor and attitude control	110 010 111 00	6 270
DC-V14	Remove maneuver inhibit Remove prop inhibit (resets DC-V13)	110 010 100 00	6 240
DC-V15	Canopus gate inhibit override	110 001 100 00	6 140
DC-V16	Start encounter backup clock	110 101 000 00	6 500
DC-V17	Cycle Canopus cone angle	110 010 001 00	6 210
DC-V18	Gyros on—inertial control (2nd-roll positive increment)	110 100 100 00	6 440
DC-V19	Gyros off—normal control (resets DC-V15, DC-V18, & DC-V20)	110 100 010 00	6 420
DC-V20	Remove roll control	110 111 100 00	6 740
DC-V21	Roll override-negative increment	110 111 010 00	6 720
DC-V22	Antenna pointing angle change	110 111 001 00	6 710

Table 23. (Cont'd)

Command number	Command name	Command address	
		Binary	Octal
DC-V23	Arm second prop maneuver	110 001 111 00	6 170
DC-V24	Begin DAS encounter mode (switch to data mode 3) (planet sensor power on) (switch plasma probe to mode 3)	110 100 001 00	6 410
DC-V25	Science on/overload inhibit override Begin encounter sequence (tape recorder power on) (energize terminator sensor) (battery charger to boost mode)	110 010 010 00	6 220
DC-V26	Turn off science (battery charger to boost mode)	110 011 110 00	6 360
DC-V27	Initiate midcourse maneuver	110 100 111 00	6 470
DC-V28	Switch battery charger (tape recorder electronics off)	110 110 110 10	6 662
DC-V29	Arm first prop maneuver	110 001 010 00	6 120
QC-V1	Maneuver command bits to CC&S		
QC-V1-1	(Pitch turn duration)	110 011 000 11-10	6 303-2
QC-V1-2	(Roll turn duration)	110 011 000 00-01	6 300-1
QC-V1-3	(Motor burn duration)	110 011 000 10-11	6 302-3

Table 24. Description of commands

Command	Effect
DC-V1	Transfers the data encoder to mode 1 operation (all engineering words) as soon as the transfer is acceptable to the data encoder transfer logic.
DC-V2	Transfers the data encoder to mode 2 operation (20 engineering words, 40 science words) as soon as the transfer is acceptable to the data encoder transfer logic; applies 2.4-kHz power to the science instruments.

Table 24. (Cont'd)

Command	Effect
DC-V3	Switches tape recorder data tracks (playback only).
DC-V4	Transfers the data encoder to mode 4/1 operation (recorded data or real-time engineering data) as soon as the transfer is acceptable to the data encoder transfer logic. (If recorded data are available from the tape recorder, recorded data are telemetered; if no recorded data are present (at end of tapes), then engineering data in mode 1 are telemetered.) Stops tape recorder record mode if in operation.
DC-V5	Transfers the data encoder from one bit rate to the other. The data encoder can operate at either 8-1/3 or 33-1/3 bps.
DC-V6	Transfers the data encoder from one (ADC/PNG) to the other. The data encoder has two ADC/PNGs, A and B.
DC-V7	Transfers the radio from one power amplifier to the other. The radio subsystem has two power amplifiers, A (traveling wave tube) and B (cavity).
DC-V8	Changes the radio from one exciter to the other. The adio subsystem has two exciters, A and B.
DC-V9	Turns the spacecraft radio ranging receiver either on or off.
DC-V10	Causes the radio subsystem circulator switches to be conditioned so that the spacecraft transmits via the high-gain antenna and receives via the low-gain antenna.
DC-V11	Causes the radio subsystem circulator switches to be conditioned so that the spacecraft transmits and receives via the high-gain antenna.
DC-V12	Causes the radio subsystem circulator switches to be conditioned so that the spacecraft transmits and receives via the low-gain antenna.
DC-V13	Removes the attitude control excitation power from CC&S control lines so that the attitude control functions that are controlled by the CC&S are disabled. DC-V13 also prevents the pyrotechnics control circuitry from firing the motor start and stop squibs.
DC-V14	Reverses the state of all the relays acted upon by DC-V13. DC-V14, therefore, is a reset for DC-V13 and reverts the attitude control and pyrotechnics subsystems back to CC&S control.

Table 24. (Cont'd)

Command	Effect
DC-V15	Causes the Canopus sensor roll error signal to be applied to the roll gas jet electronics at all times, regardless of whether or not the roll acquisition logic is satisfied, and also prevents the roll search signal from being applied to the roll channel, and roll acquisition logic violations from turning on the gyros.
DC-V16	Toggles DAS Timer A. Used to issue backup commands for the encounter sequence.
DC-V17	Causes a step change in the Canopus sensor cone angle by changing the voltage on the deflection plates of the Canopus sensor's image dissector.
DC-V18	Turns on the gyros (in the inertial mode) and the Canopus sensor sun shutter and turns off the Canopus sensor. DC-V18 also turns on the turn command generator and conditions the attitude control circuitry for commanded roll turns. Each successive DC-V18 causes positive roll rotation of 2.25 deg.
DC-V19	Serves as the reset for DC-V15, DC-V18, and DC-V20.
DC-V20	Turns off the Canopus sensor and turns on the Canopus sensor sun shutter; also inhibits the roll acquisition logic from turning on the gyros.
DC-V21	Simulates a Canopus acquisition logic violation, turns on the gyros, and applies a negative roll search signal to the roll gas jet electronics, thereby causing the spacecraft to counterclockwise roll search to acquire a new target. Each successive DC-V21 will also cause the spacecraft to roll turn 2.25 deg if preceded by a DC-V18.
DC-V22	Commands pyro to activate a pinpuller that allows the antenna to change position for optimizing the S-band occultation experiment.
DC-V23	Sets relays in the pyrotechnics subsystem so that CC&S commands M-6 and M-7 are routed to the squibs allotted to the second motor burn.
DC-V24	Begins DAS encounter mode. Enable DAS timer B (toggle). Switch to data mode 3; planet sensor power on; switch plasma probe to encounter format.

Table 24. (Cont'd)

Command	Effect
DC-V25	Begins encounter sequence. Applies power to the terminator sensor and to the tape recorder. Enables the battery charger boost mode and removes booster regulator overload inhibit.
DC-V26	Removes 2.4-kHz power from all the science loads (tape recorder 2.4-kHz power remains on); also enables the battery charger boost mode.
DC-V27	Starts the maneuver sequence by issuing the CC&S command M-1 (turn on gyros), by applying power to the maneuver clock, and by removing the maneuver clamp and a flip-flop reset signal from the CC&S maneuver circuitry.
DC-V28	Transfers the battery charger from the charge mode to the boost enable mode or vice versa. Turns off 2.4-kHz power to the tape recorder.
DC-V29	Sets relays in the pyrotechnics subsystem so that the CC&S commands M-6 and M-7 are routed to the squibs allotted to the first motor burn.
QC-V1-1	Sets pitch turn polarity and preloads the CC&S pitch shift register so that at a counting rate of 1 pps the register will fill in the required time interval for the attitude control subsystem to pitch turn the spacecraft the amount required for a given midcourse maneuver.
QC-V1-2	Sets roll turn polarity and preloads the CC&S roll shift register so that at a counting rate of 1 pps the register will fill in the required time interval for the attitude control subsystem to roll turn the spacecraft the amount required for a given midcourse maneuver.
QC-V1-3	Preloads the CC&S velocity shift register so that at a counting rate of 20 pps the register will fill in the time interval necessary for the midcourse motor to burn so that the spacecraft obtains the required velocity change for a given midcourse maneuver.

Table 25. CC&S commands

CC&S command No.	Function and purpose
L-1	Deploy solar panels. Backup for separation initiated timer.
L-2	Turn on attitude control. Backup for pyro arming switch.
L-3	Turn on Canopus sensor.
M-1	Turn on gyros for warmup. Maneuver start command. If CC&S command L-3 has failed to operate, the automatic resetting of M-1 after the maneuver will turn the Canopus sensor off. This condition can be corrected by sending DC-V13 after completion of the maneuver.
M-2	All axes to inertial control. Places all three gyros in position mode and places gas jet system under command of gyro position errors. Turns off Canopus sensor. Turns on autopilot.
M-3	Set turn polarity.
M-4	Command X axis (pitch) turn.
M-5	Command Z axis (roll) turn.
M-6	Start motor burn.
M-7	Stop motor burn.
MT-1	Set Canopus sensor cone angle 1.
MT-2	Set Canopus sensor cone angle 2.
MT-3	Set Canopus sensor cone angle 3.
MT-4	Set Canopus sensor cone angle 4.
MT-5	Transmit high–receive low.
MT-6	Switch to 8-1/3 bps.
MT-7	Turn on tape recorder power. Start terminator sensor excitation.
MT-8	Begin DAS encounter sequence.
MT-9	Switch to mode 4.

Table 25. (Cont'd)

CC&S command No.	Function and purpose
CY-1	Following DC-V9, switches ranging receiver off; failure switching to backup transmitter and switching of antennas.

NOTE: In the case of interfaces with the attitude control subsystem, the CC&S closes or interrupts a circuit supplied by attitude control. Duration of the circuit closure or interruption depends on the function to be performed. CC&S commands L-2, L-3, and MT-1 through MT-4 are permanent changes in the circuit state. CC&S commands M-1 through M-5 require resetting after controlled periods.

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FIGURES

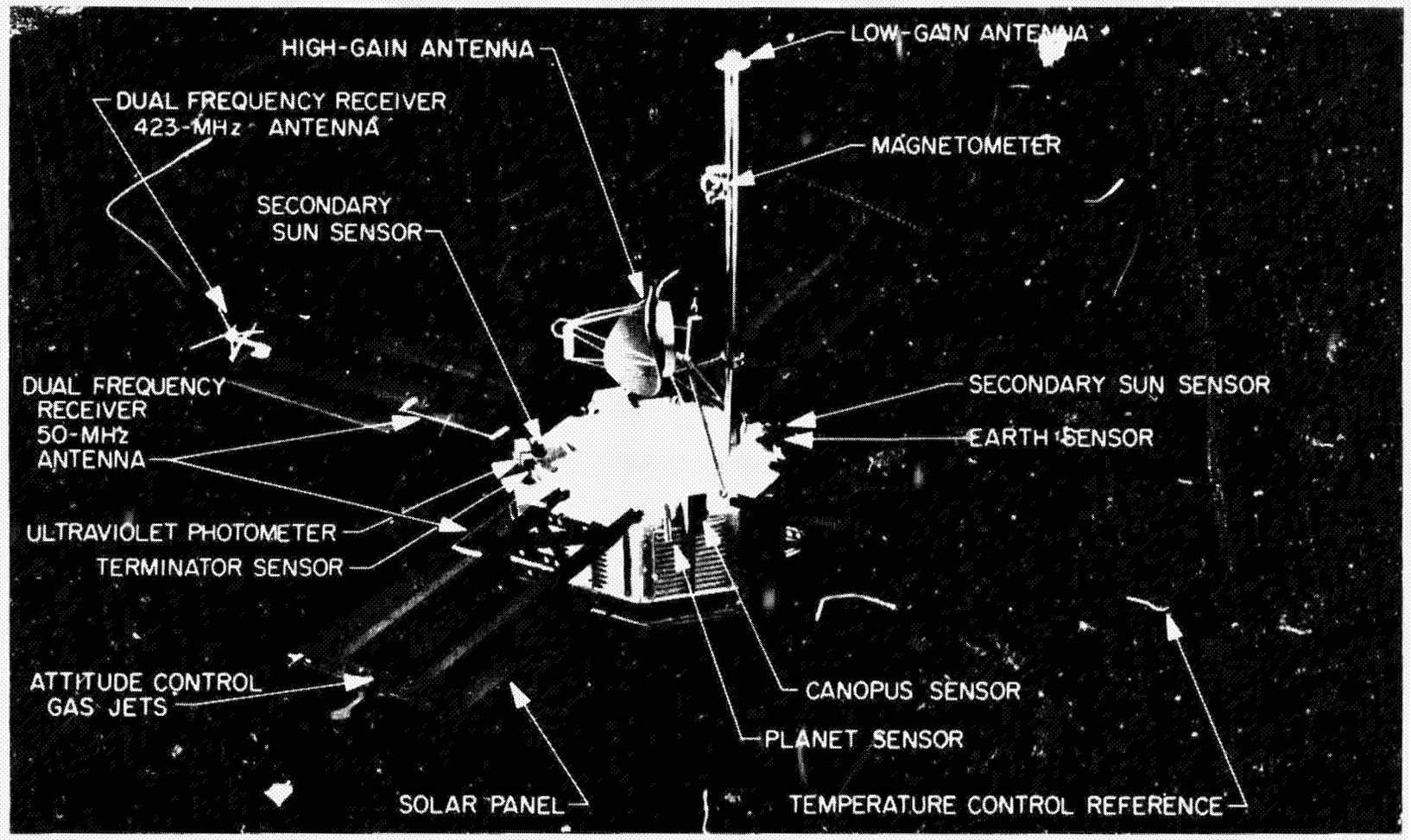


Fig. 1a. Mariner V spacecraft, earthward

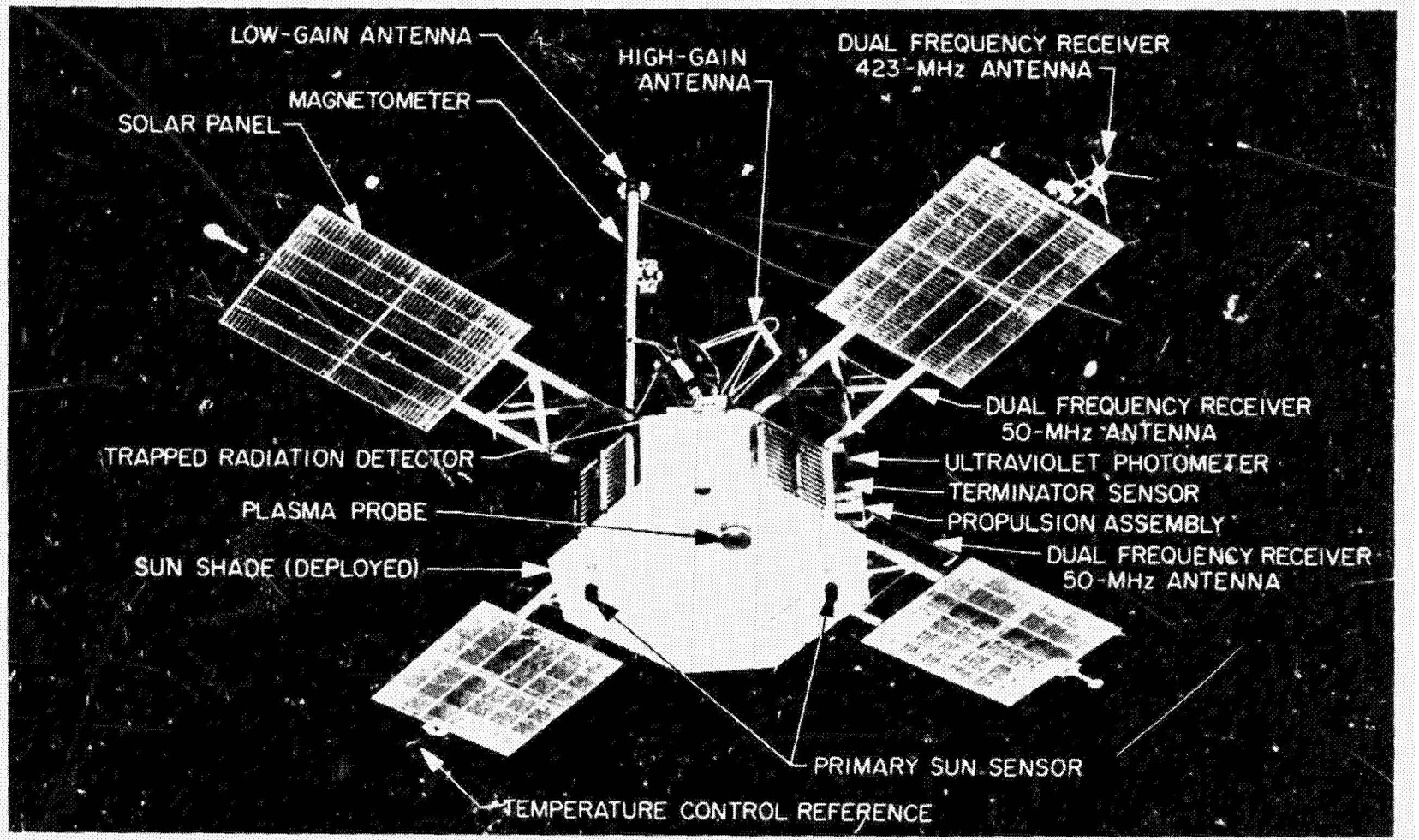


Fig. 1b. Mariner V spacecraft, sunward

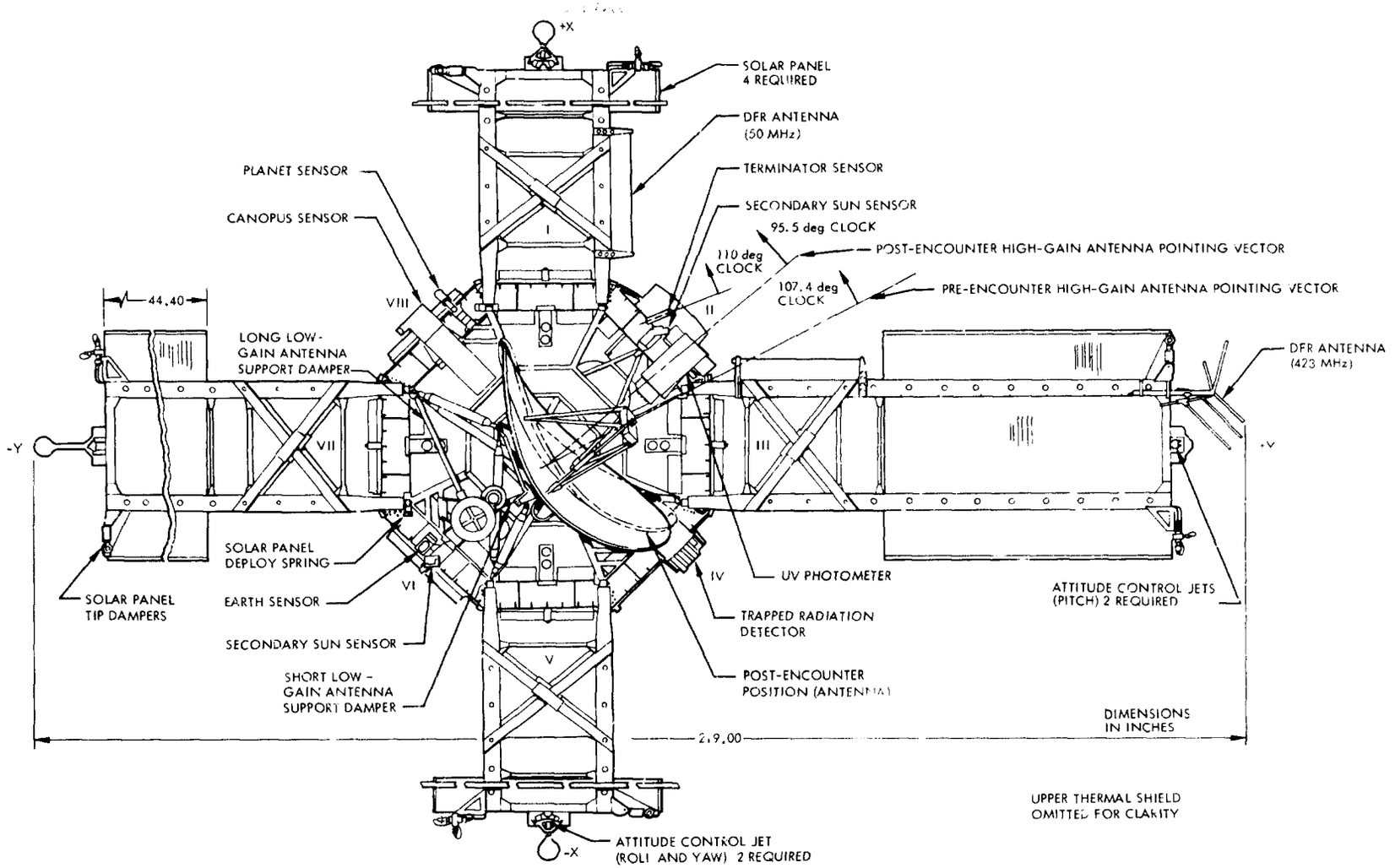


Fig. 2a Spacecraft mechanical configuration, earthward, solar panels extended

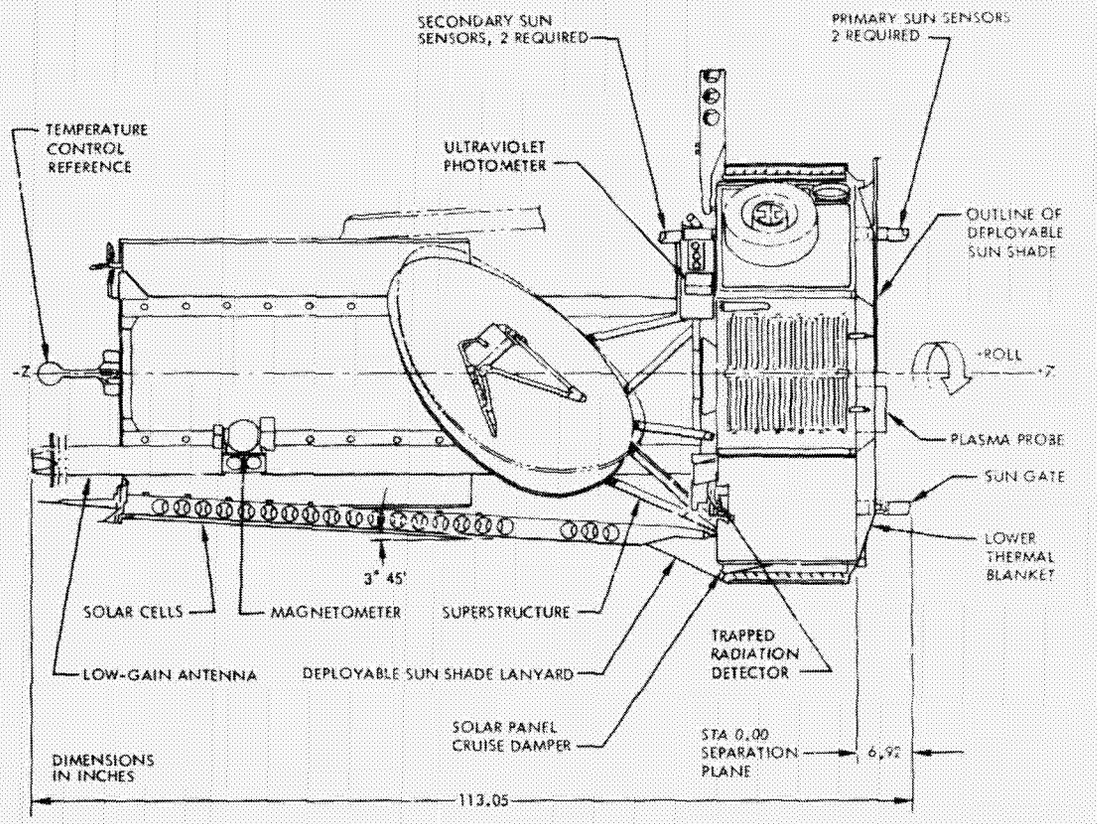


Fig. 2b. Spacecraft mechanical configuration, side view, solar panels folded

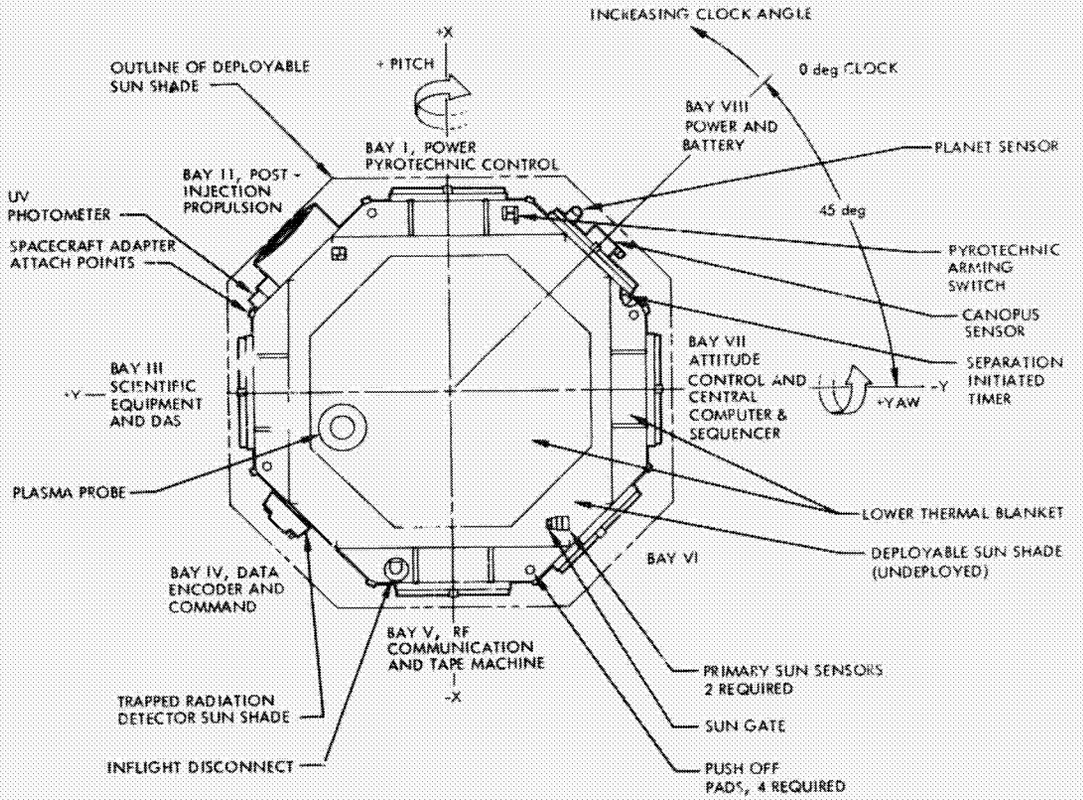


Fig. 2c. Spacecraft mechanical configuration, sunward

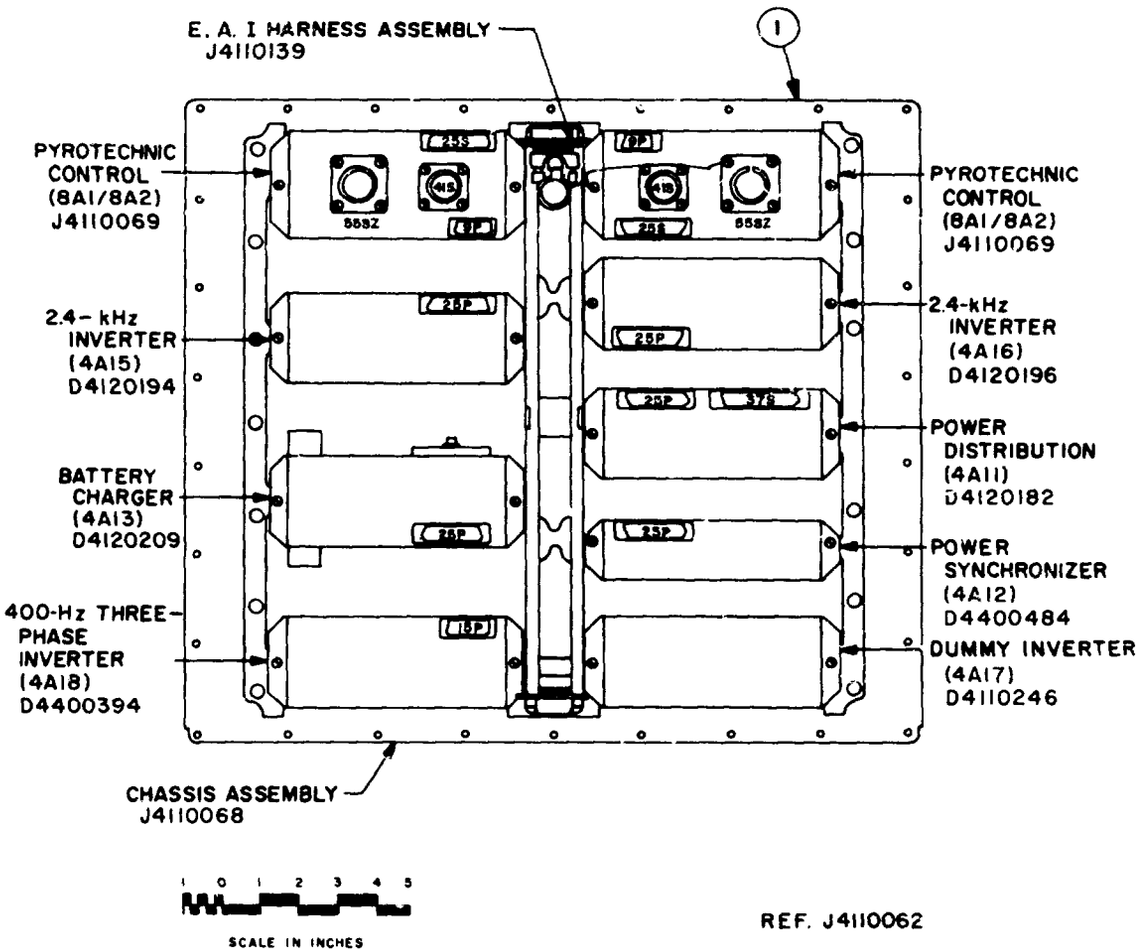


Fig. 3a. Packaging diagram, power subsystem, electronics assembly I

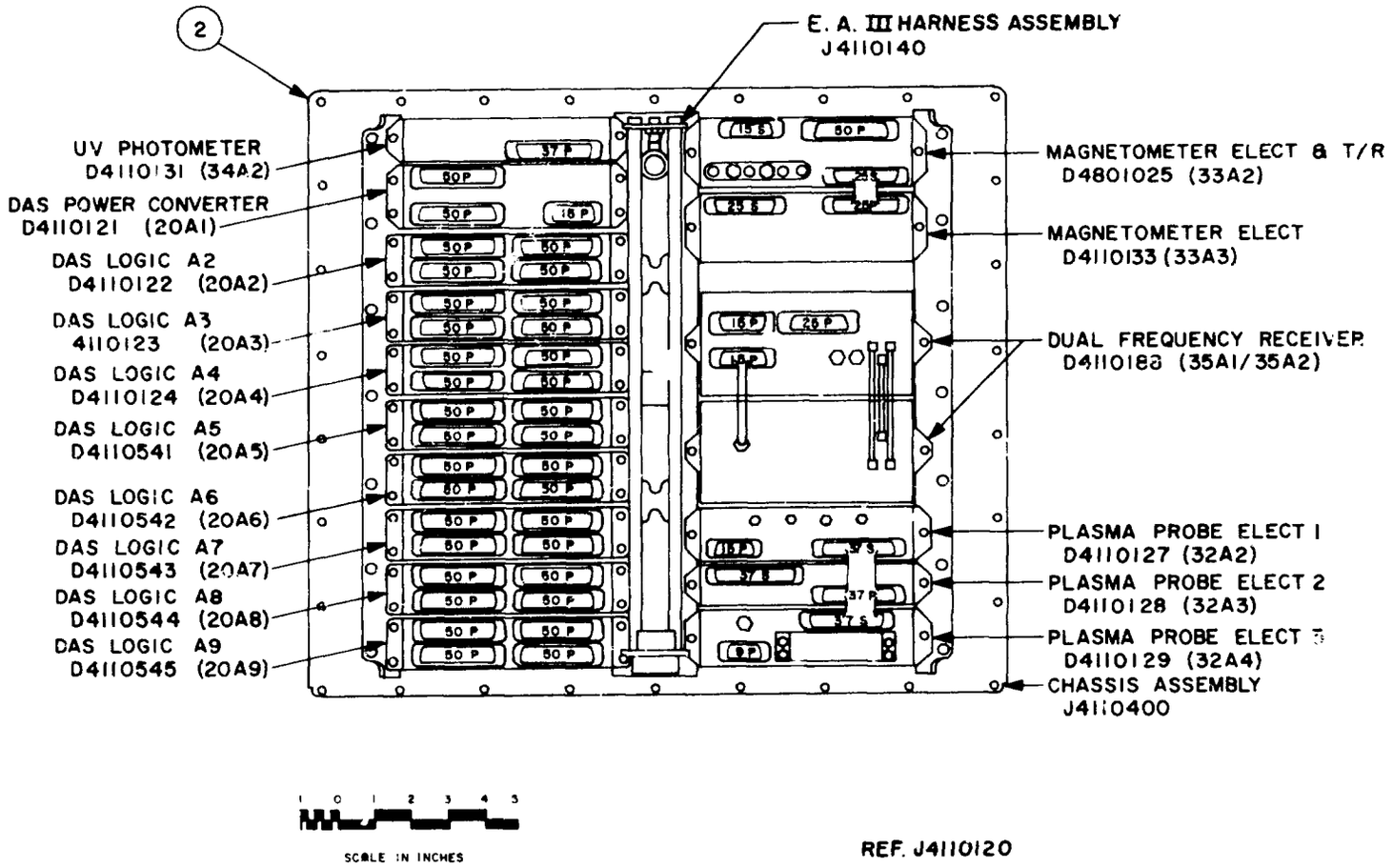


Fig. 3b. Packaging diagram, science electronics, electronics assembly III

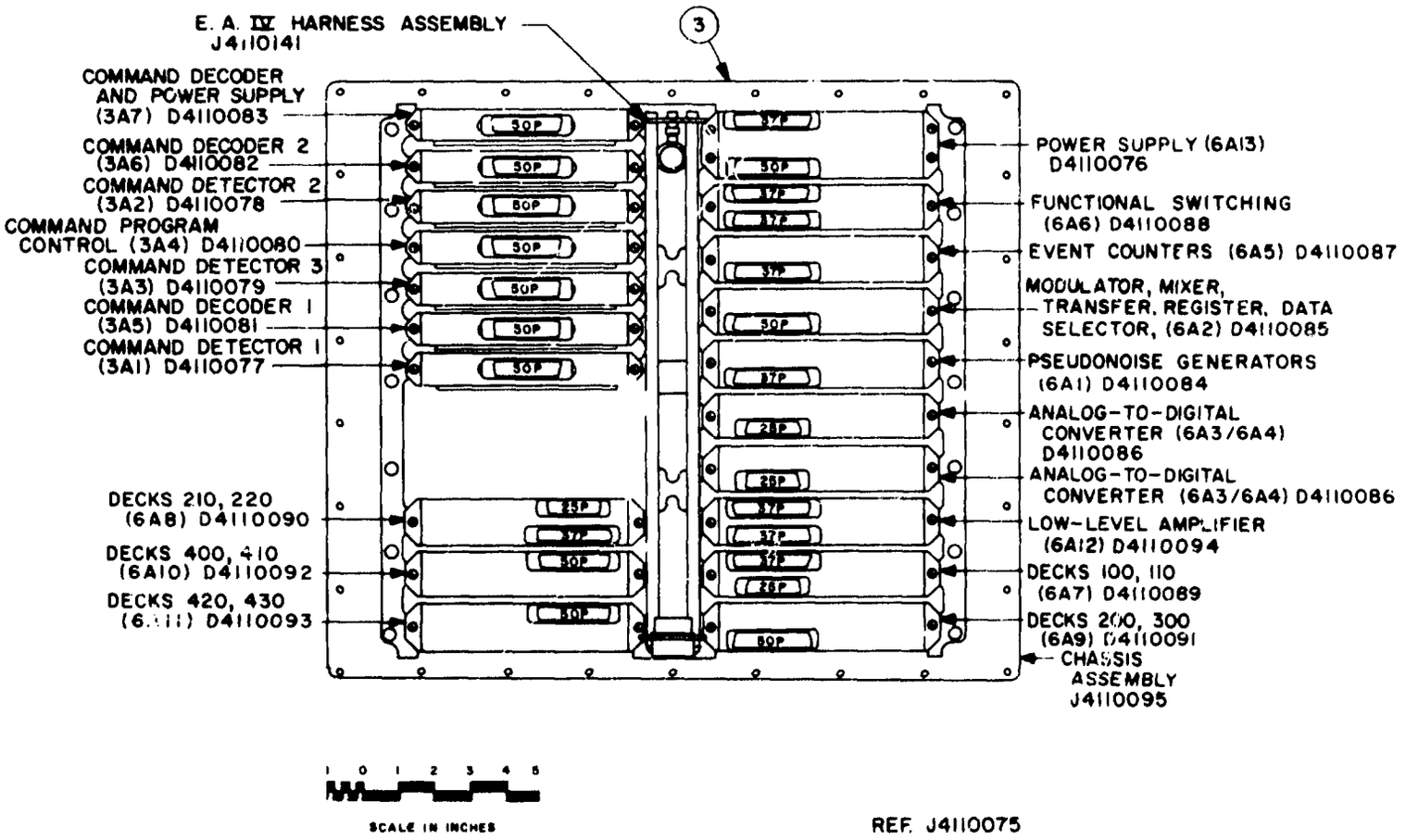


Fig. 3c. Packaging diagram, data encoder and command, electronics assembly IV

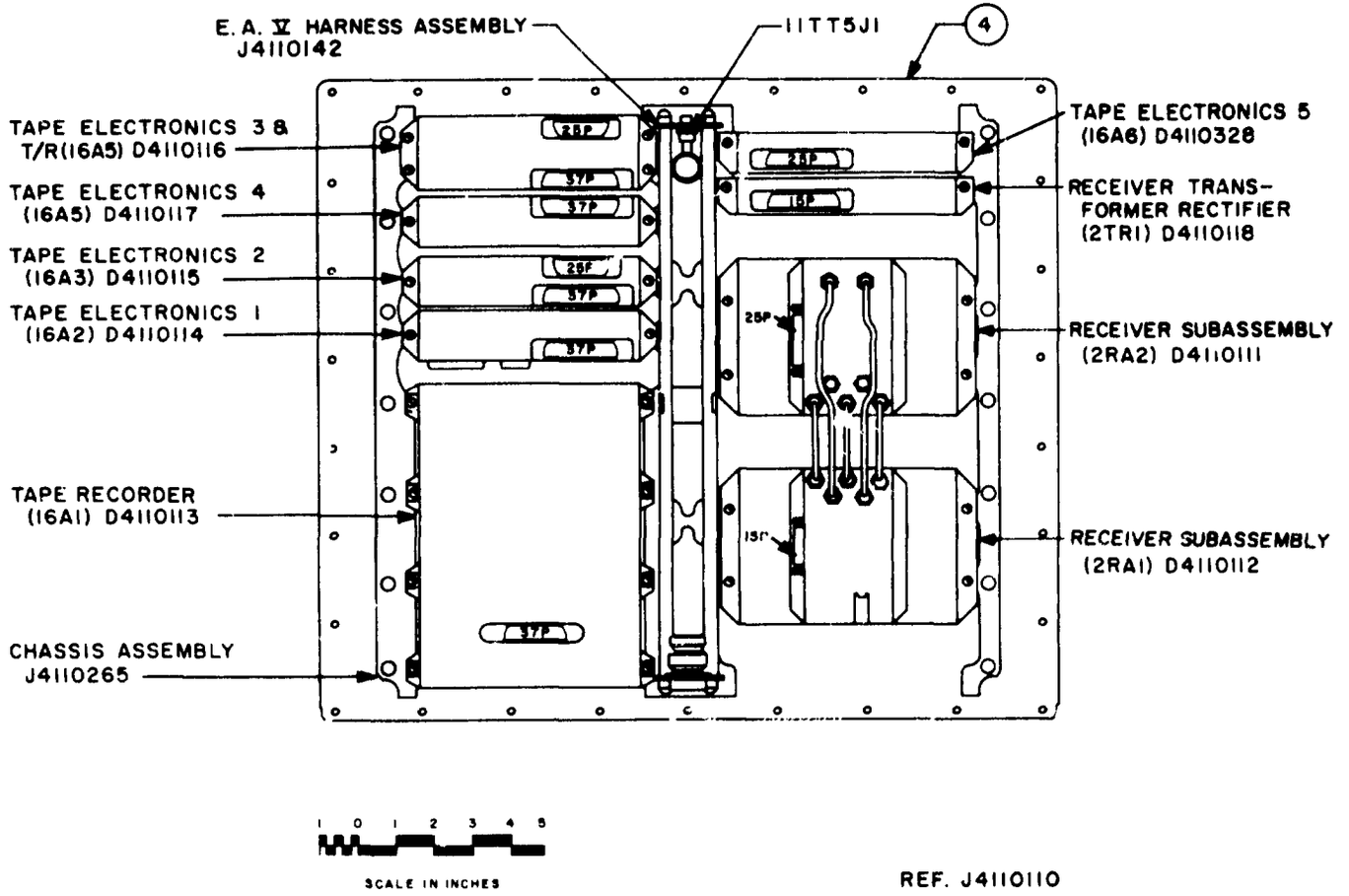


Fig. 3d. Packaging diagram, receiver and tape recorder, electronics assembly V

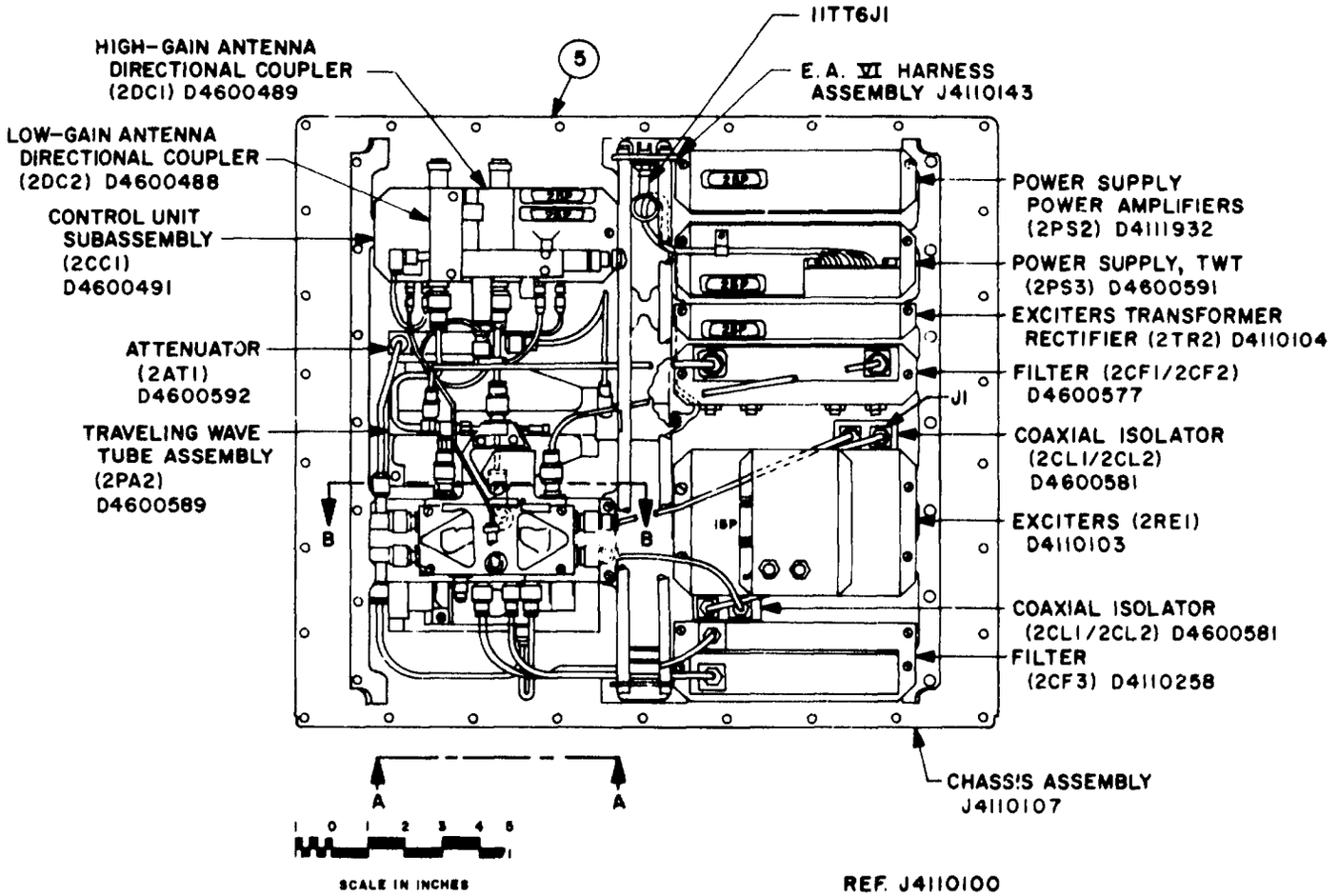


Fig. 3e. Packaging diagram, RF communications, electronics assembly VI

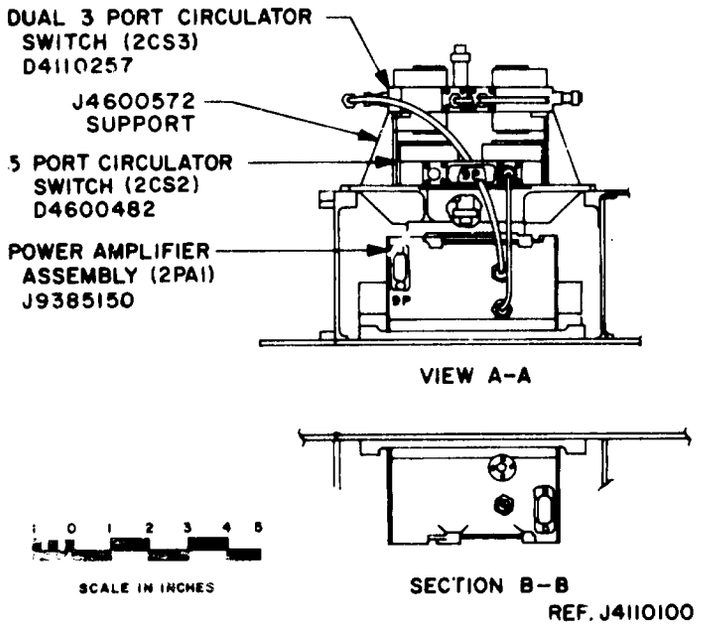


Fig. 3f. Detailed view, electronics assembly VI

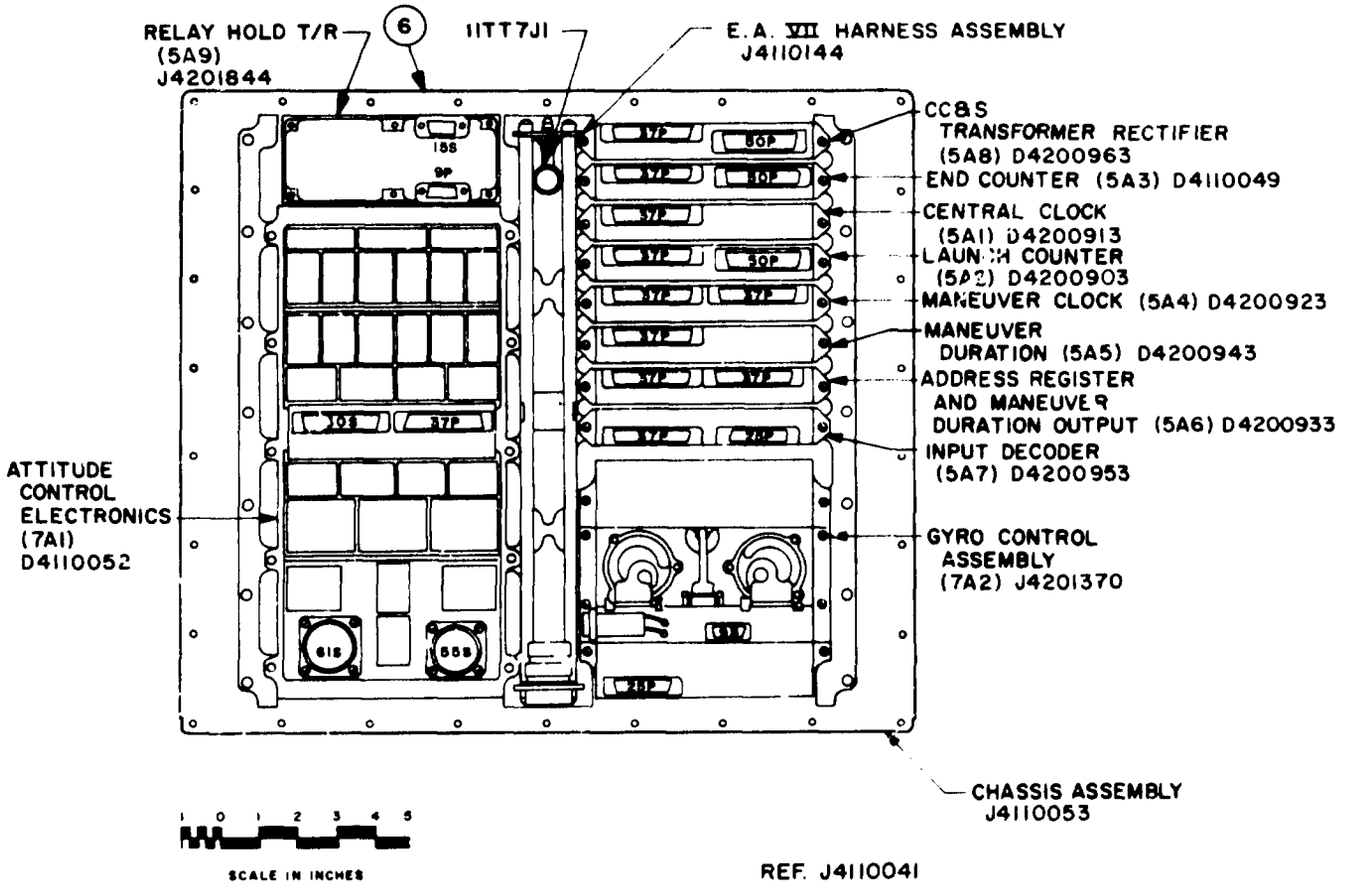


Fig. 3g. Packaging diagram, attitude control and CC&S, electronics assembly VII

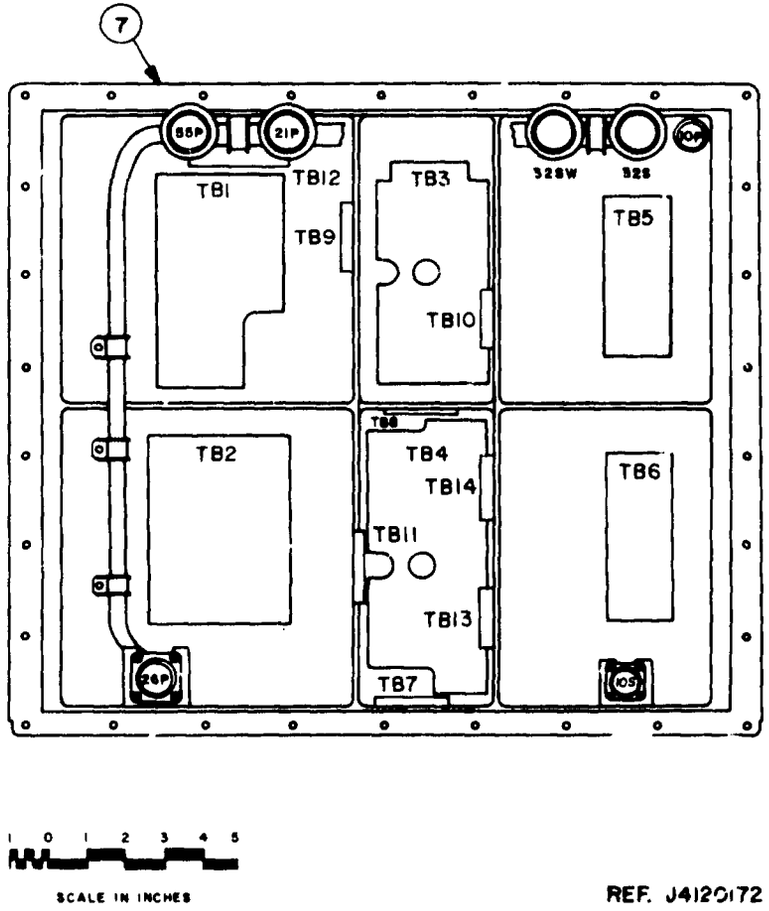


Fig. 3h. Packaging diagram, power regulator assembly, electronics assembly VIII

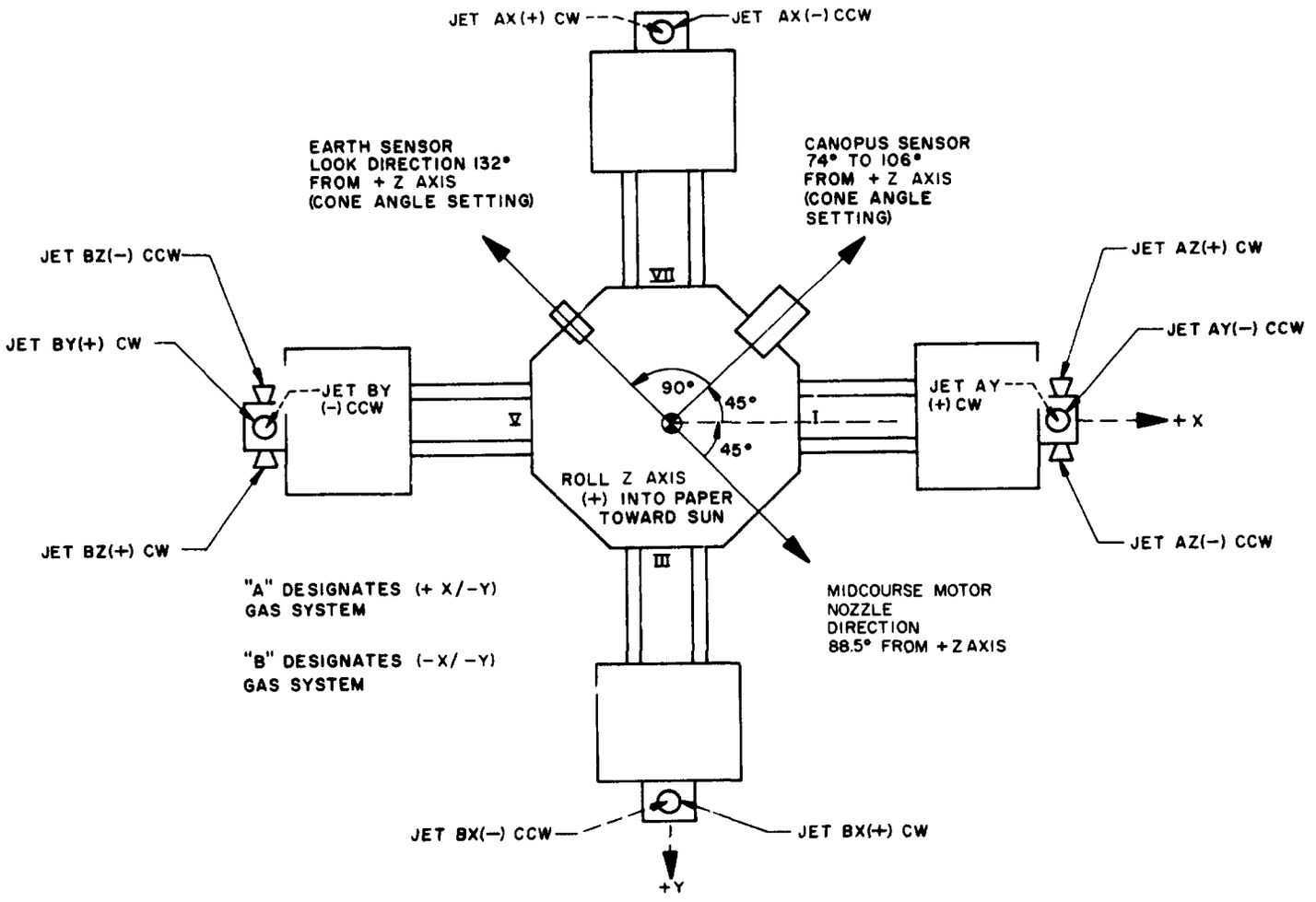
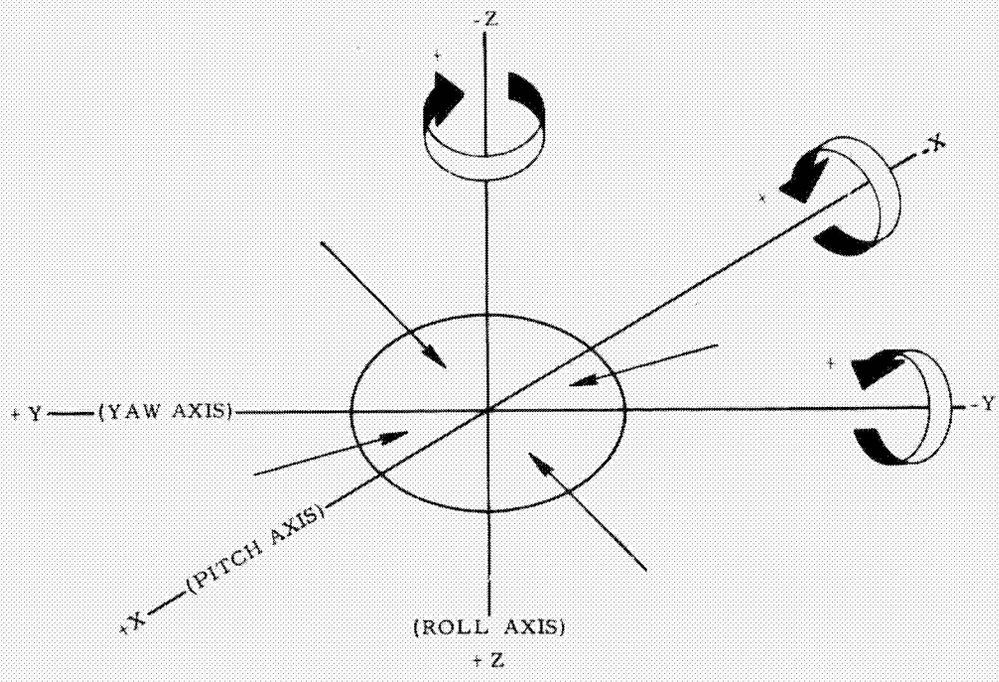


Fig. 4. Attitude control gas jet configuration



JPL SPACECRAFT
COORDINATE AXIS SYSTEM
(STANDARD RIGHT-HAND COORDINATE SYSTEM)

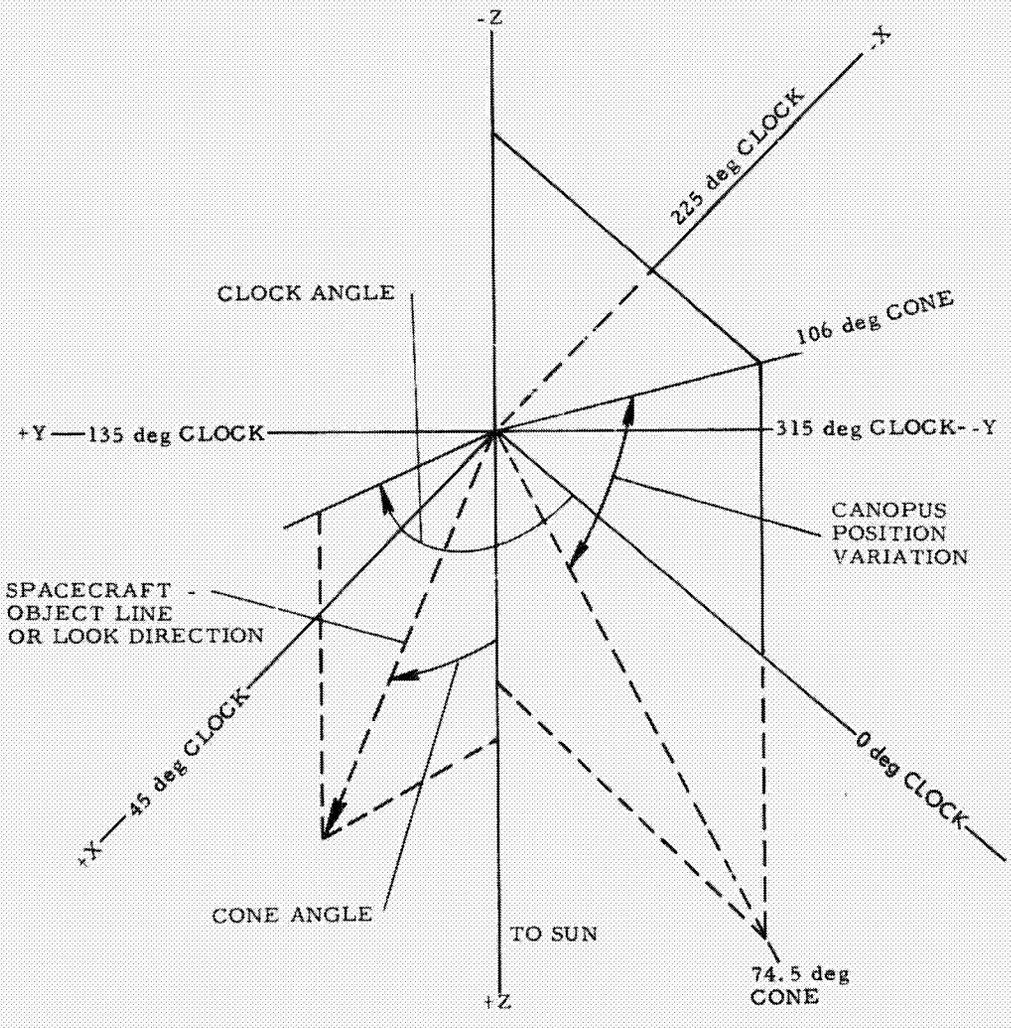


Fig. 5. Cone and clock angle convention

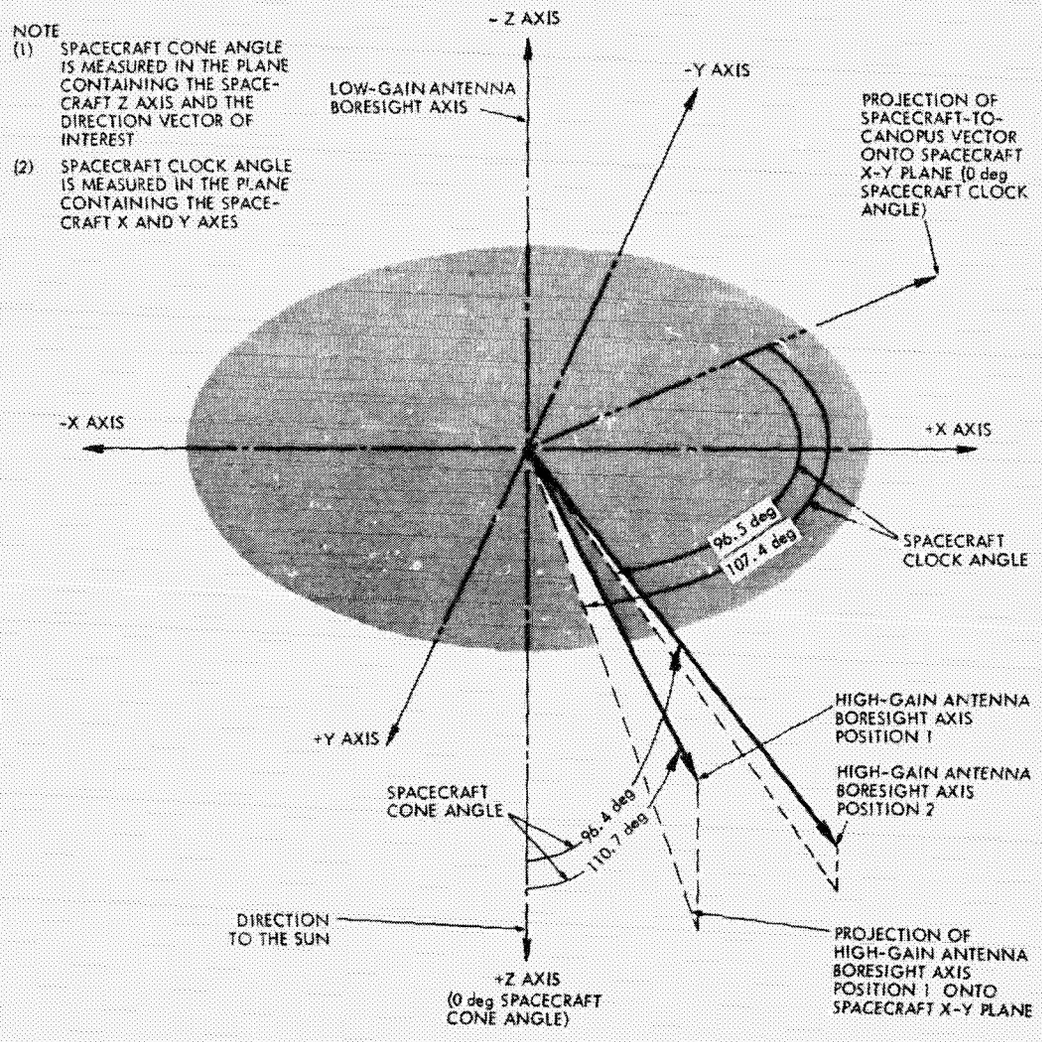


Fig. 6. Spacecraft antenna coordinate system

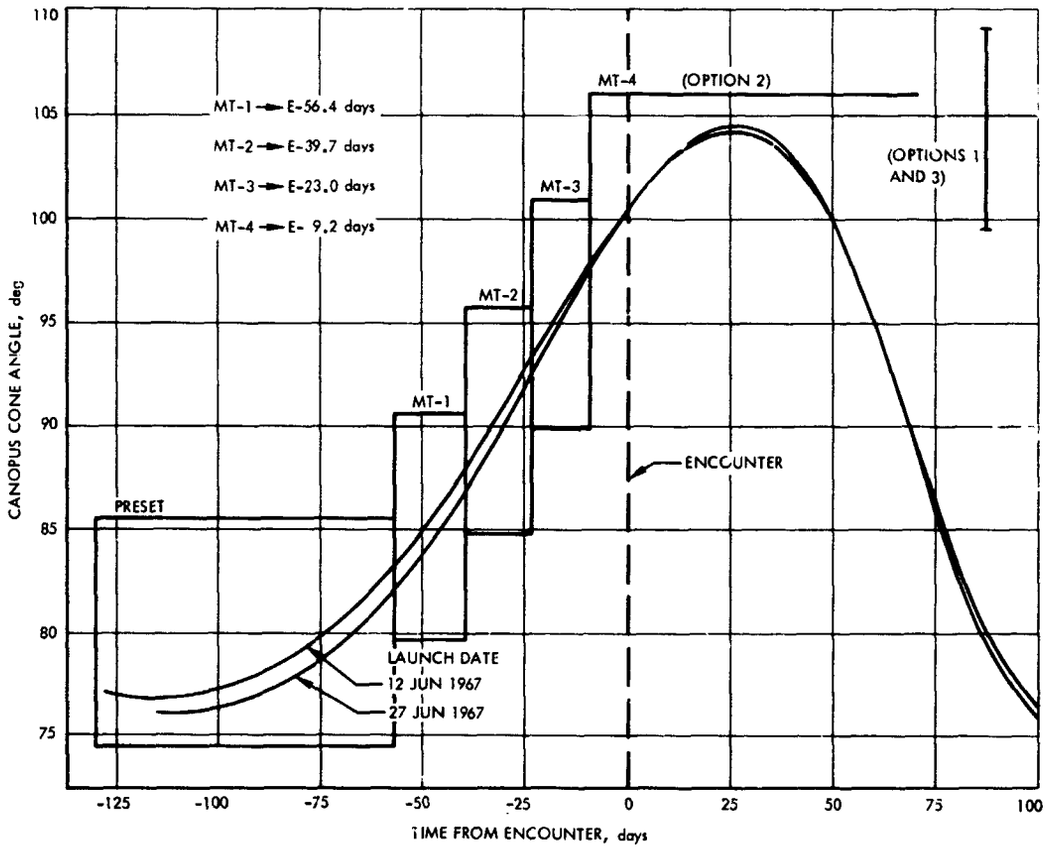


Fig. 7. Canopus sensor cone angle update

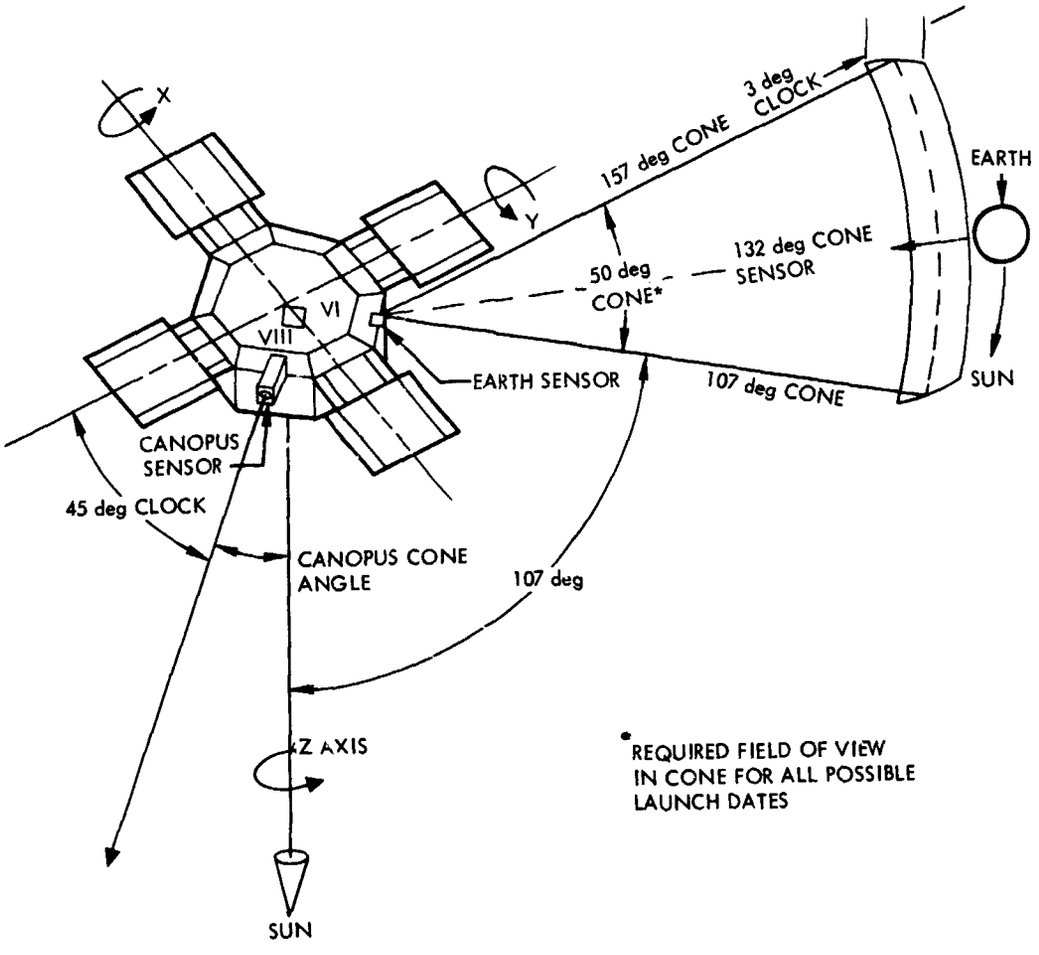


Fig. 8. Earth sensor field of view

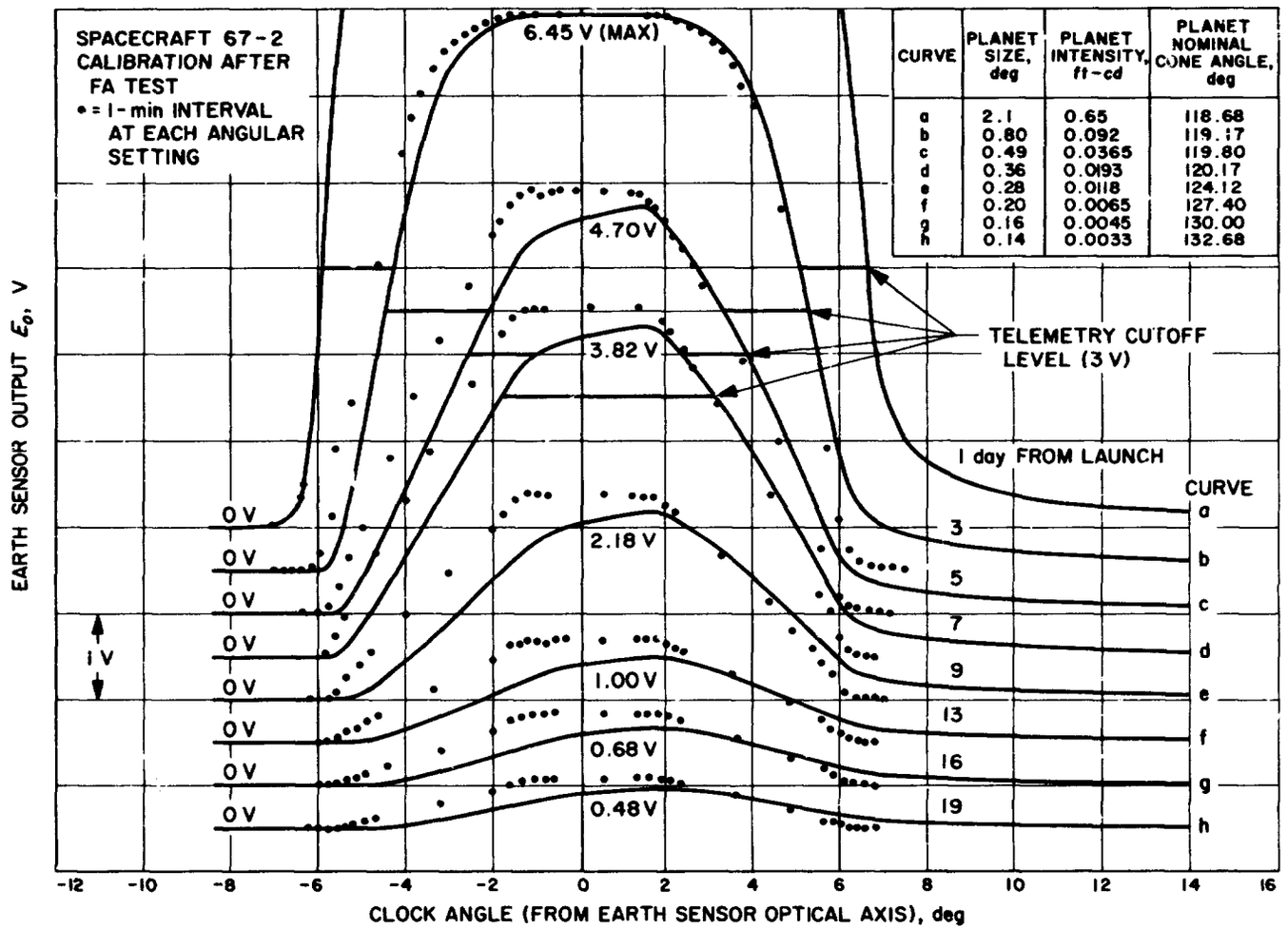


Fig. 9. Earth sensor calibration

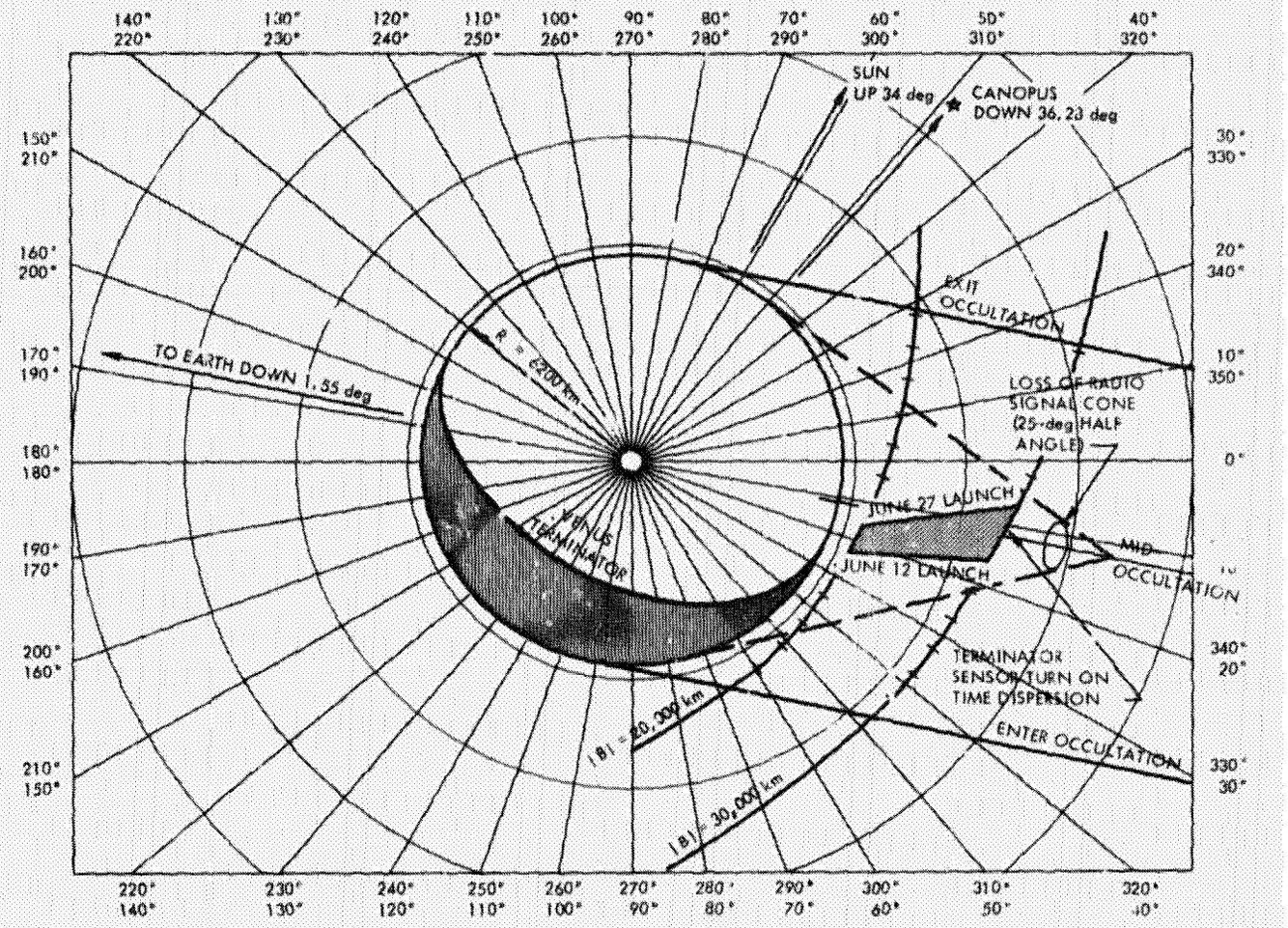


Fig. 10. Terminator sensor encounter geometry

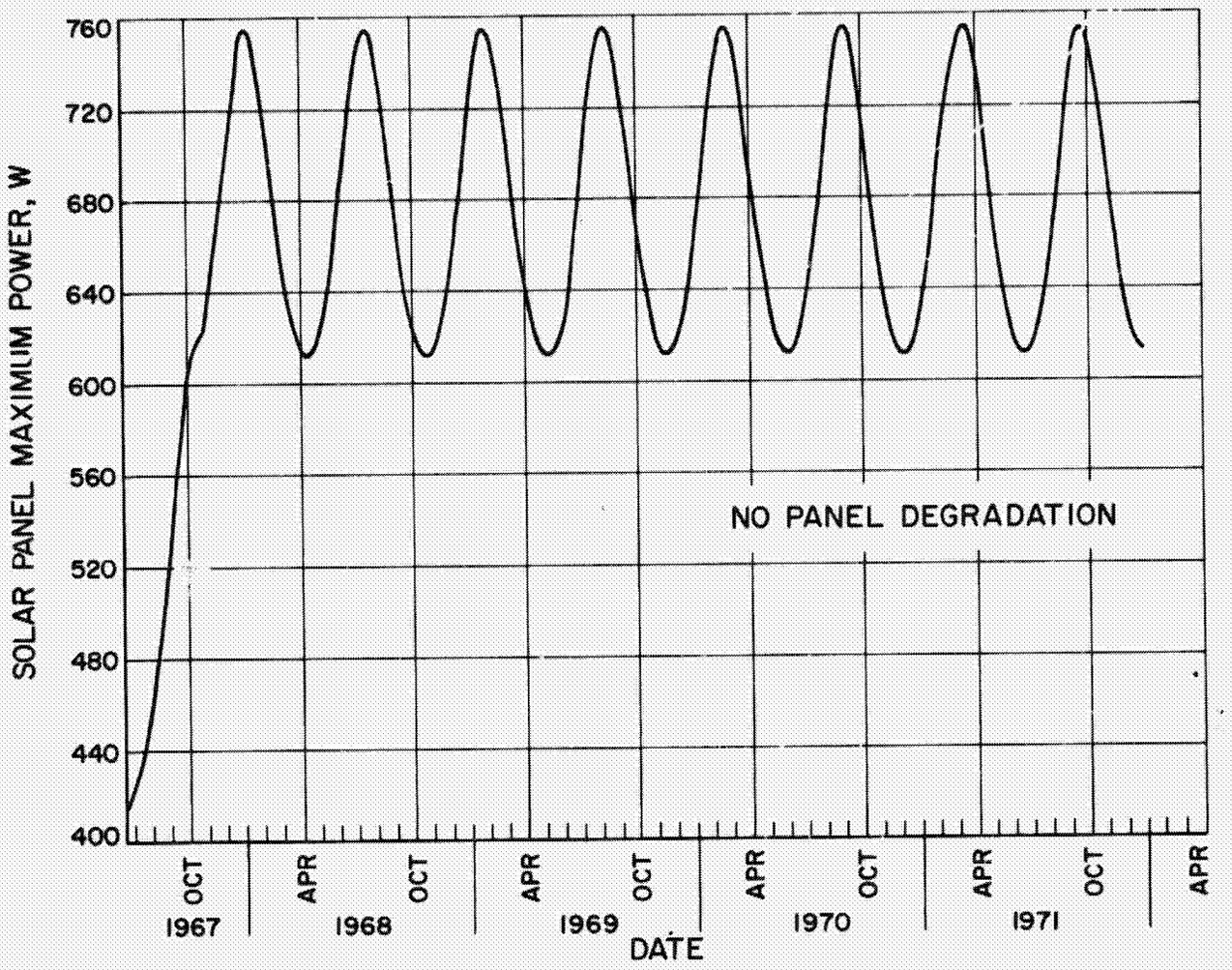


Fig. 11. Solar panel maximum power vs time from launch

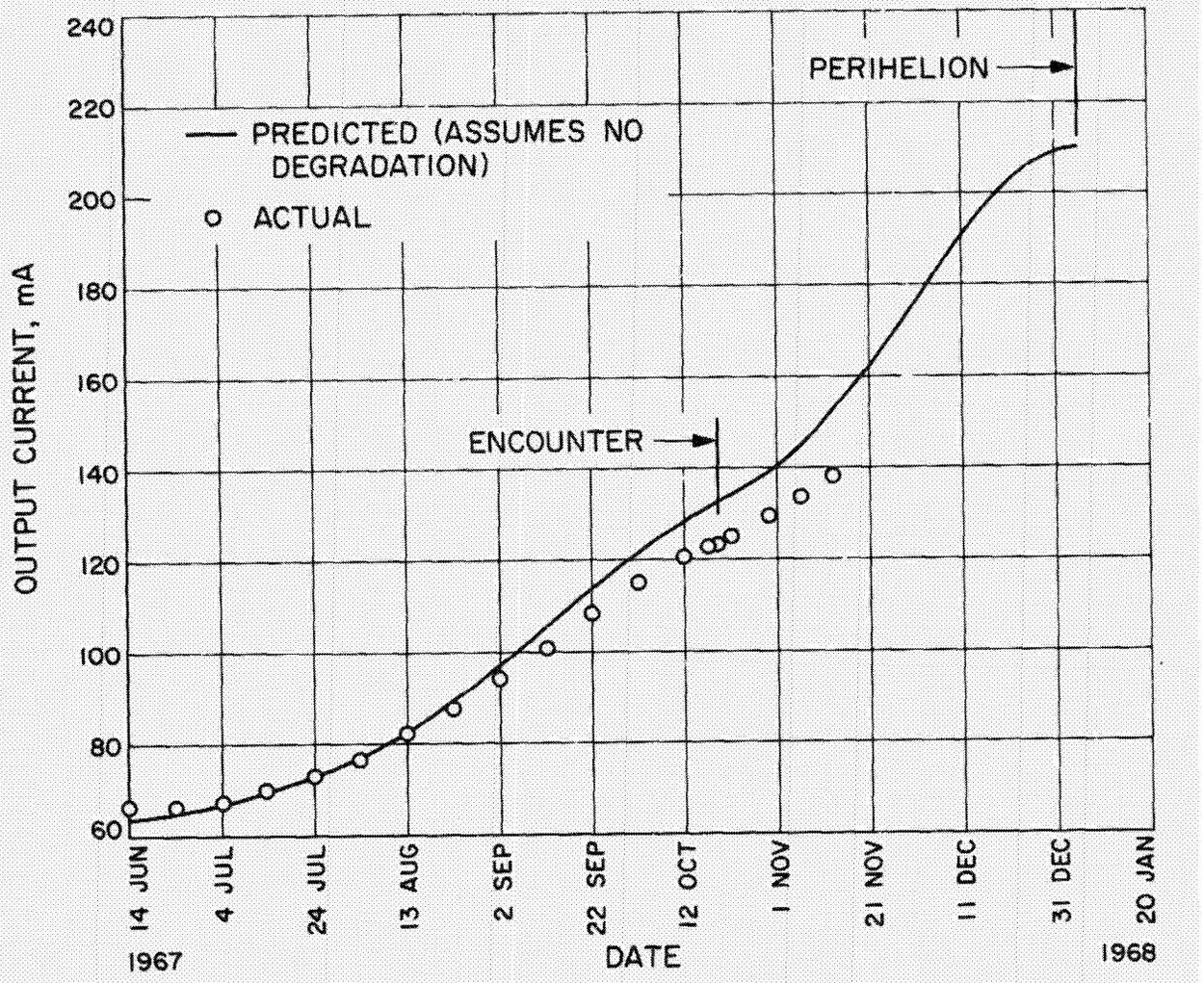


Fig. 12a. Output of experimental solar cell I_{SC}

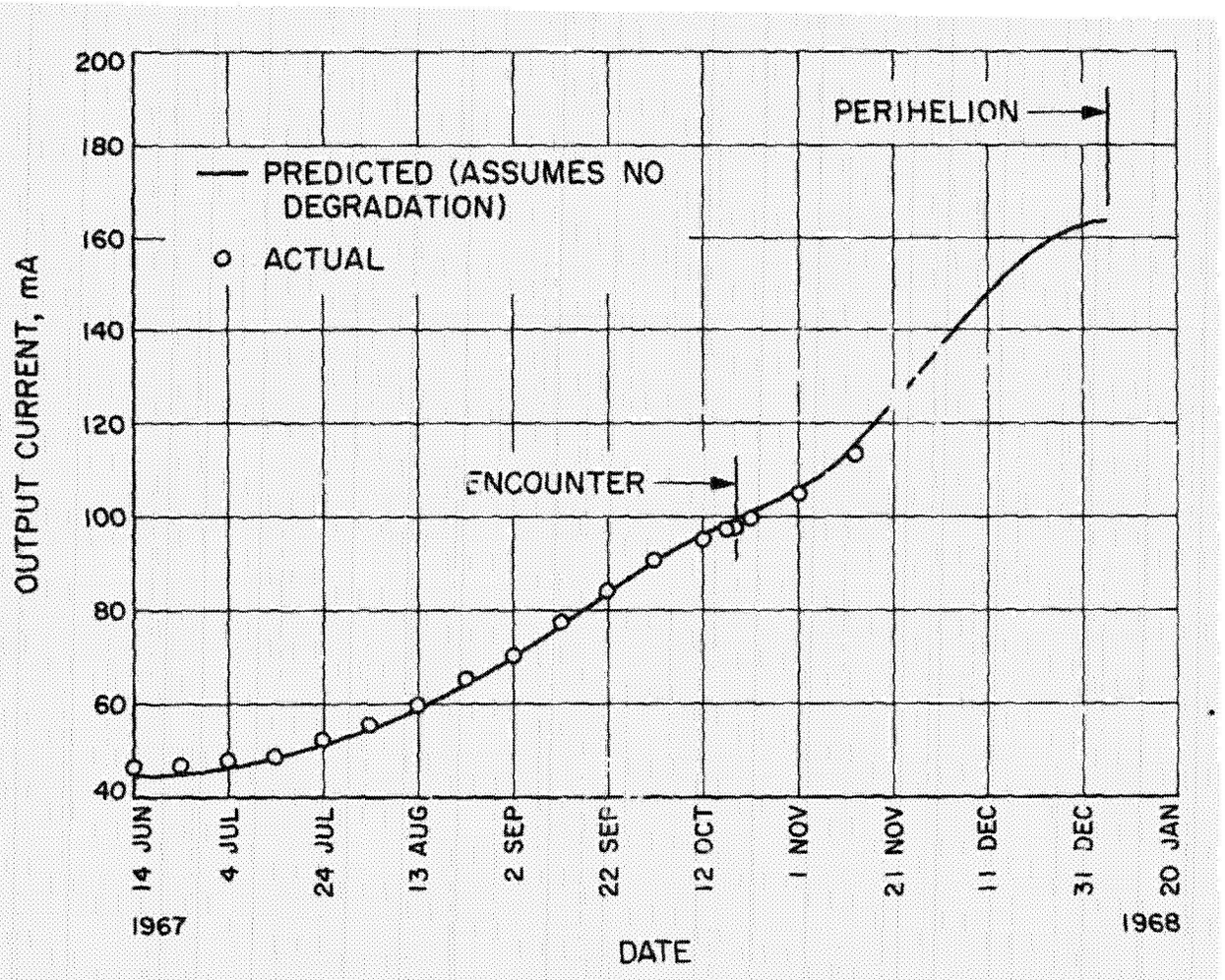


Fig. 12b. Output of experimental solar cell I_{SCR}

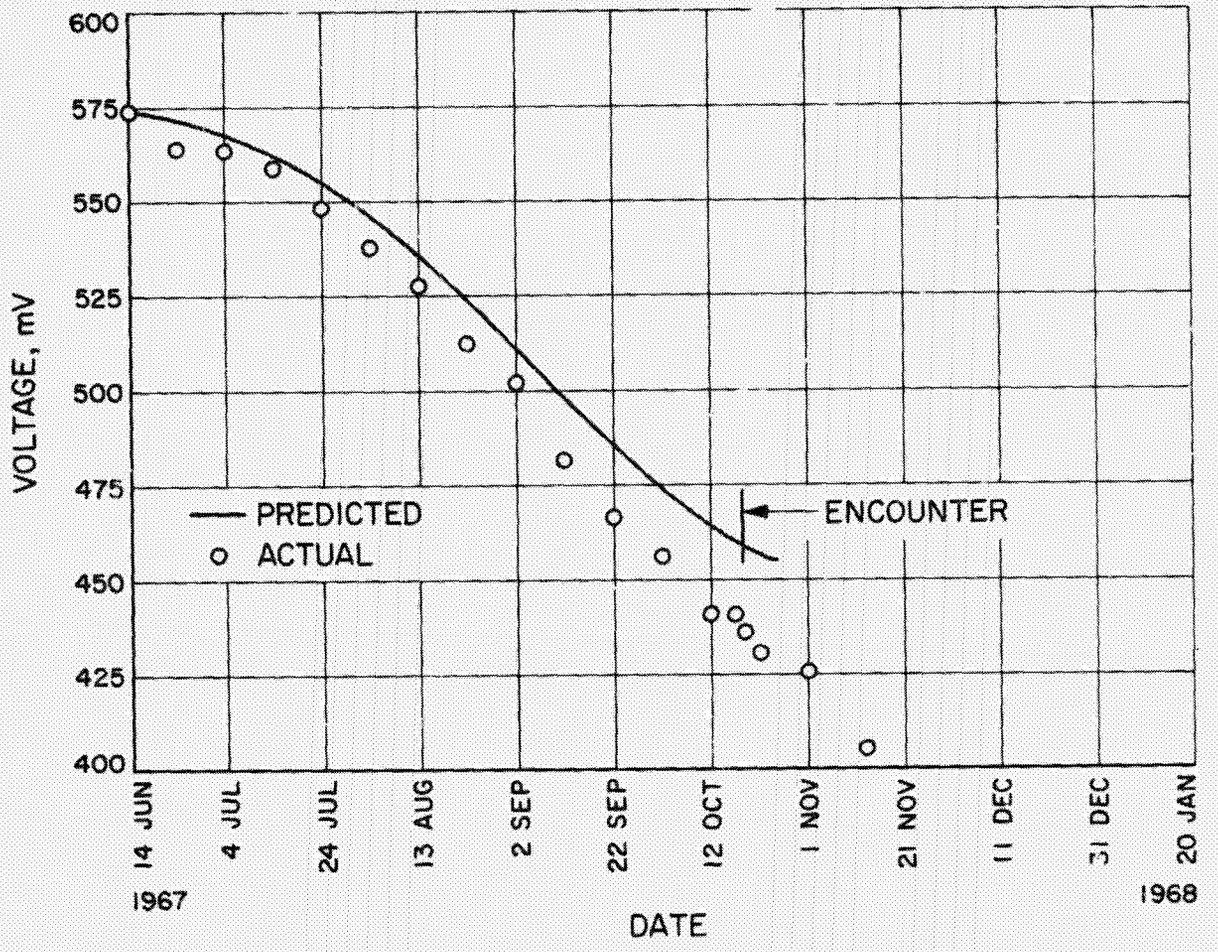


Fig. 12c. Output of experimental solar cell V_{oc}

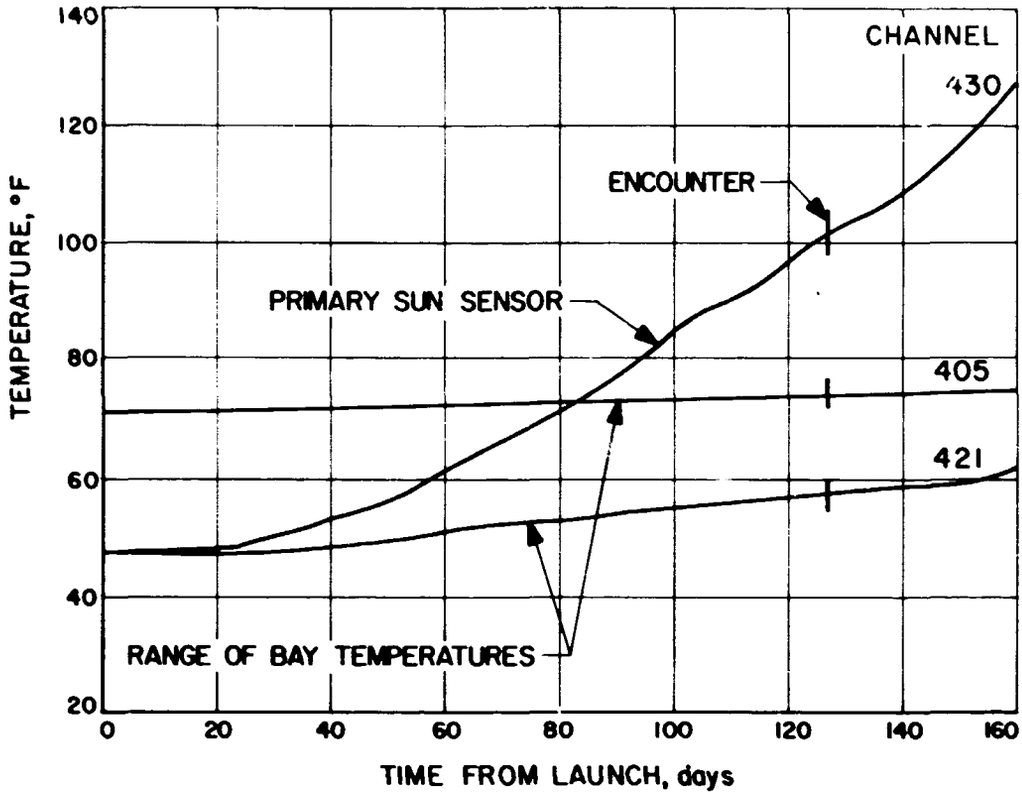


Fig. 13. Bus temperatures vs time from launch

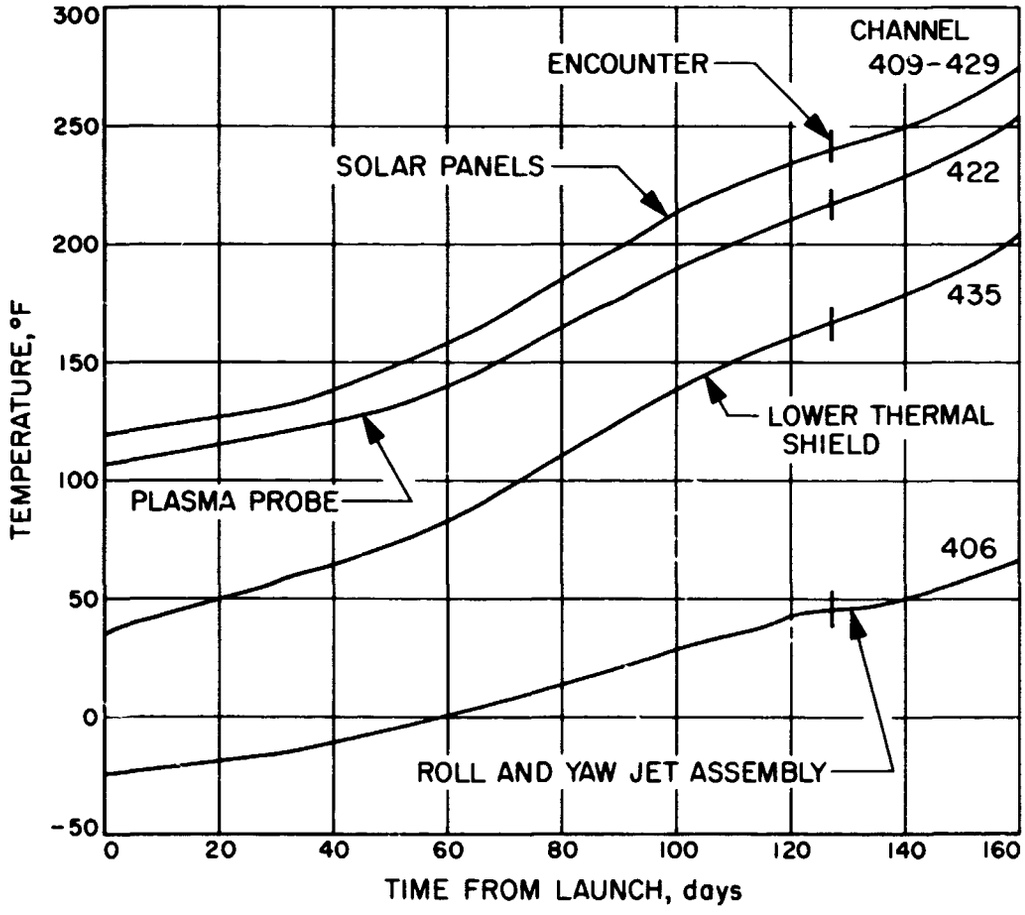


Fig. 14. Sunlit component temperatures vs time from launch

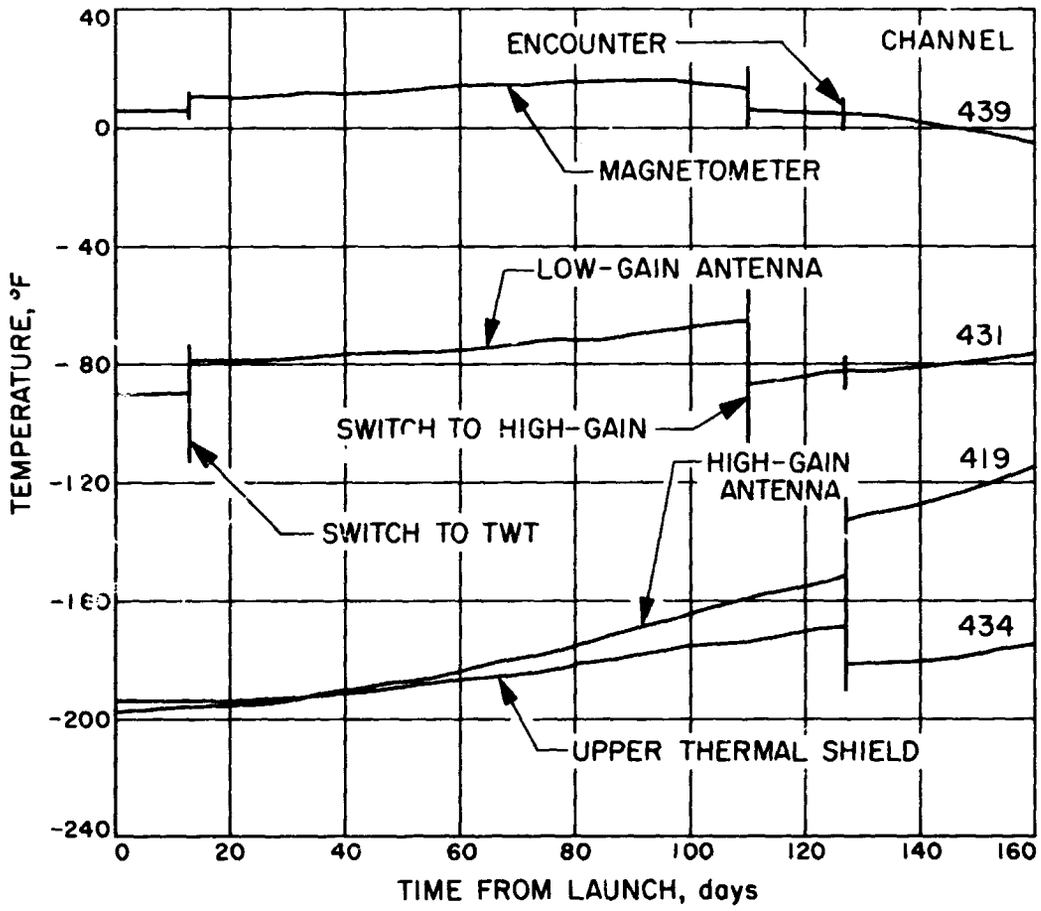


Fig. 15. Shaded component temperatures vs time from launch

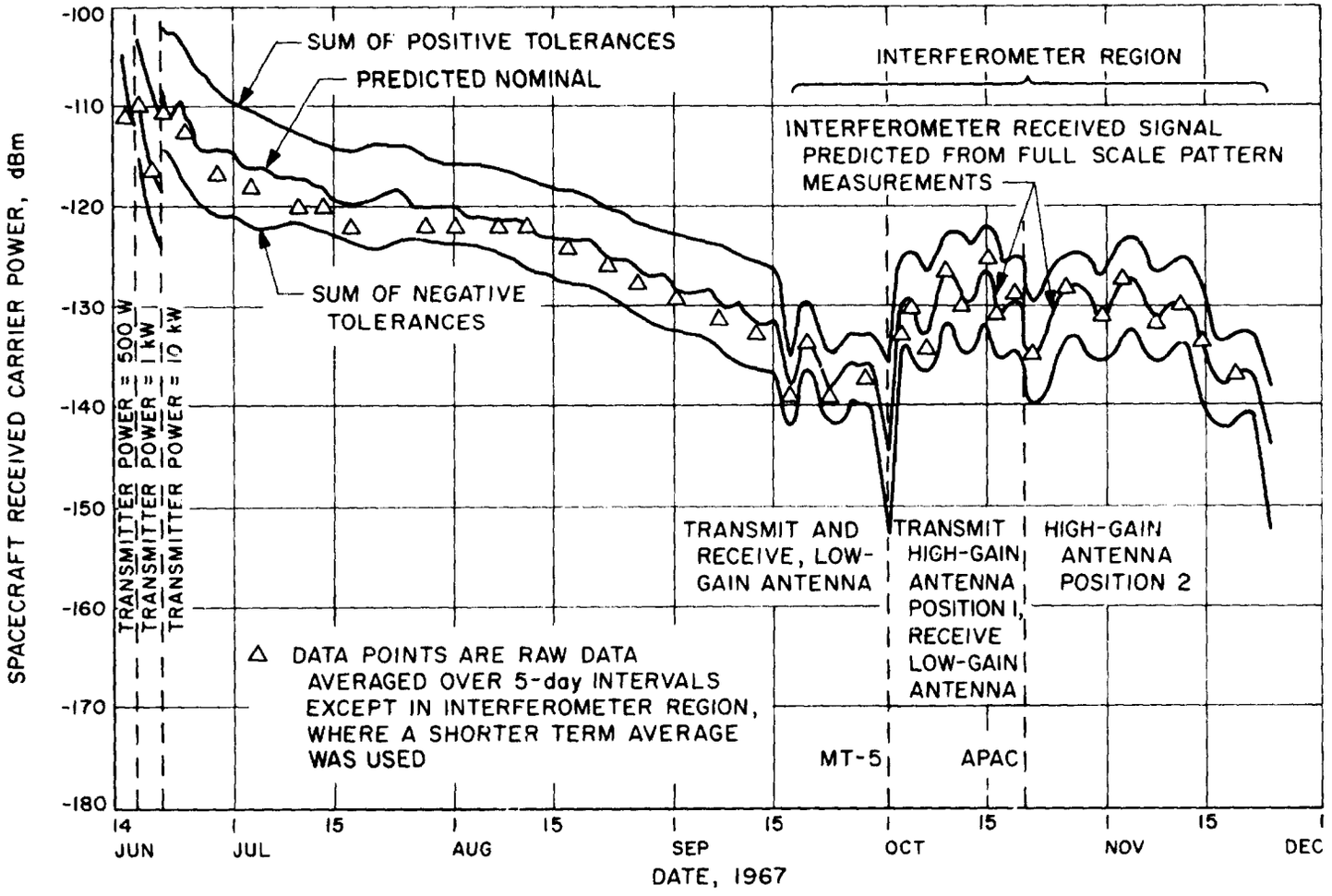


Fig. 16a. Telecommunications performance analysis, uplink, 85-ft-diameter antenna

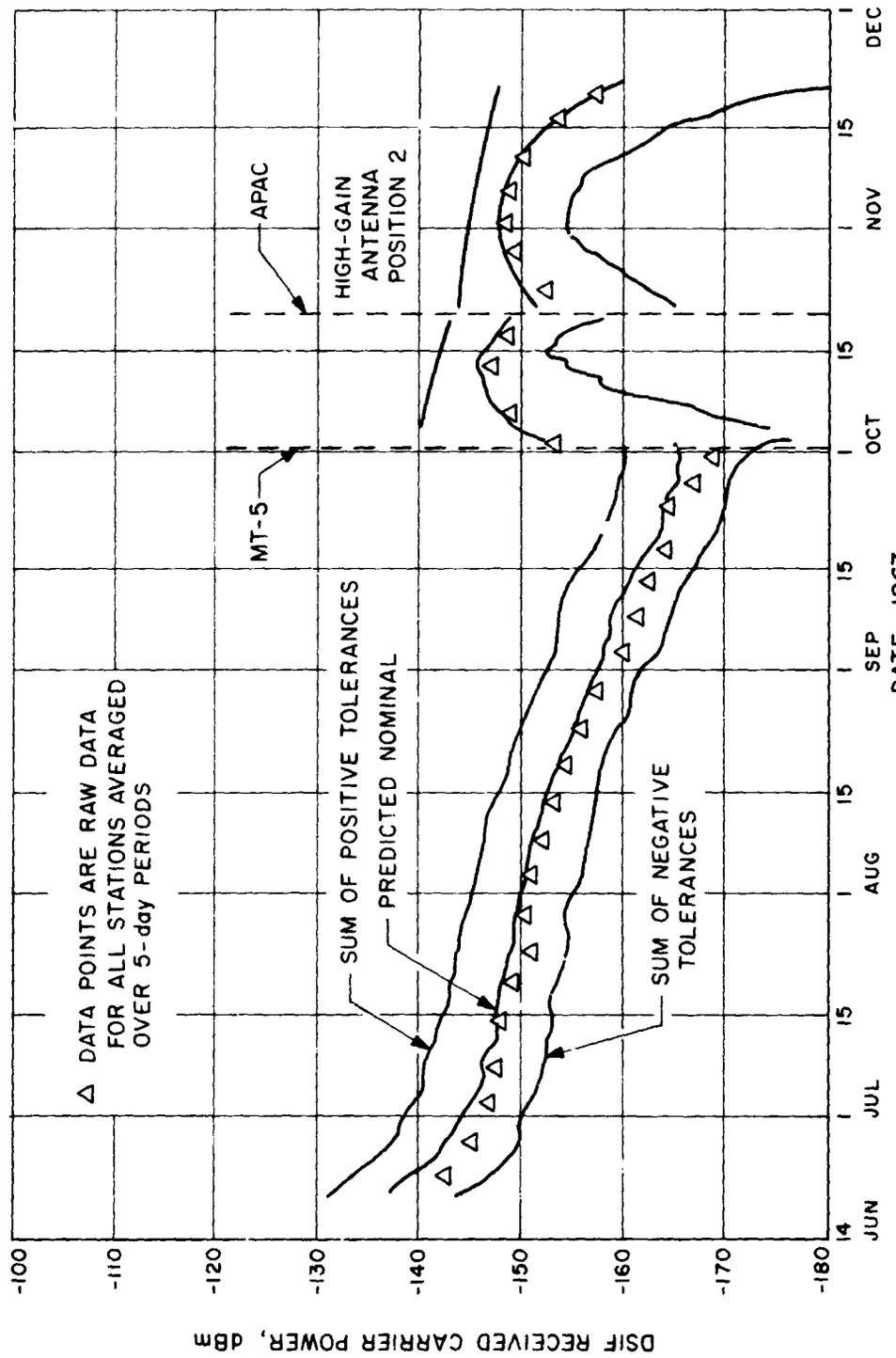


Fig. 16b. Telecommunications performance analysis, downlink, 85-ft-diameter antenna

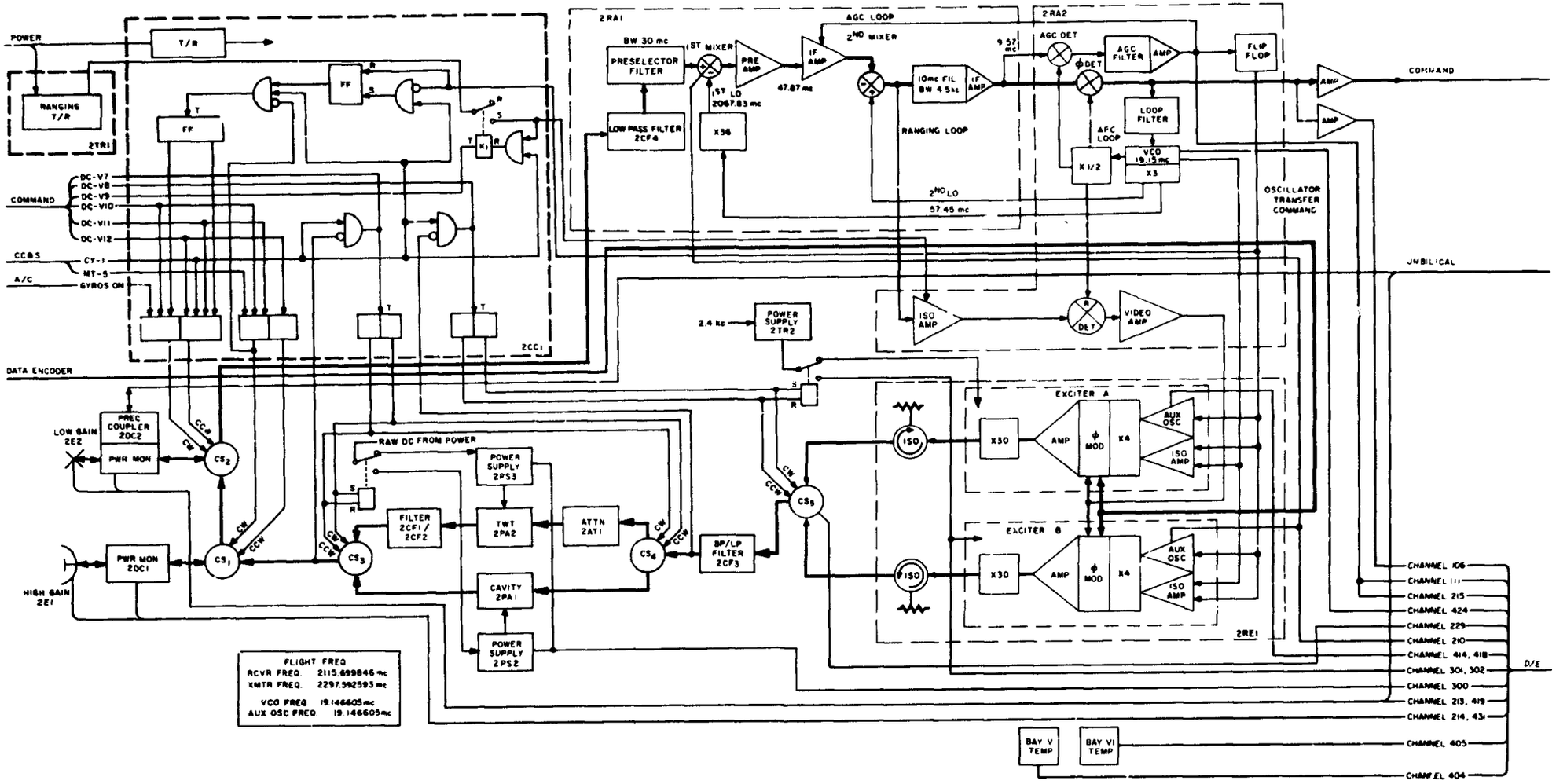


Fig. 17. Radio subsystem

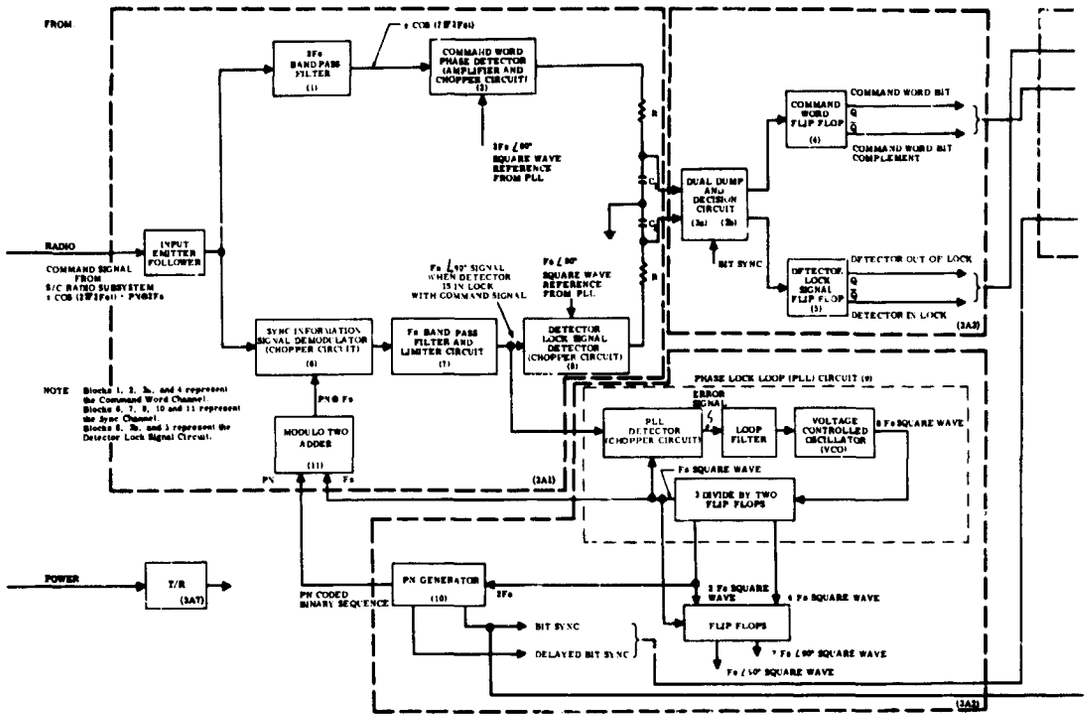
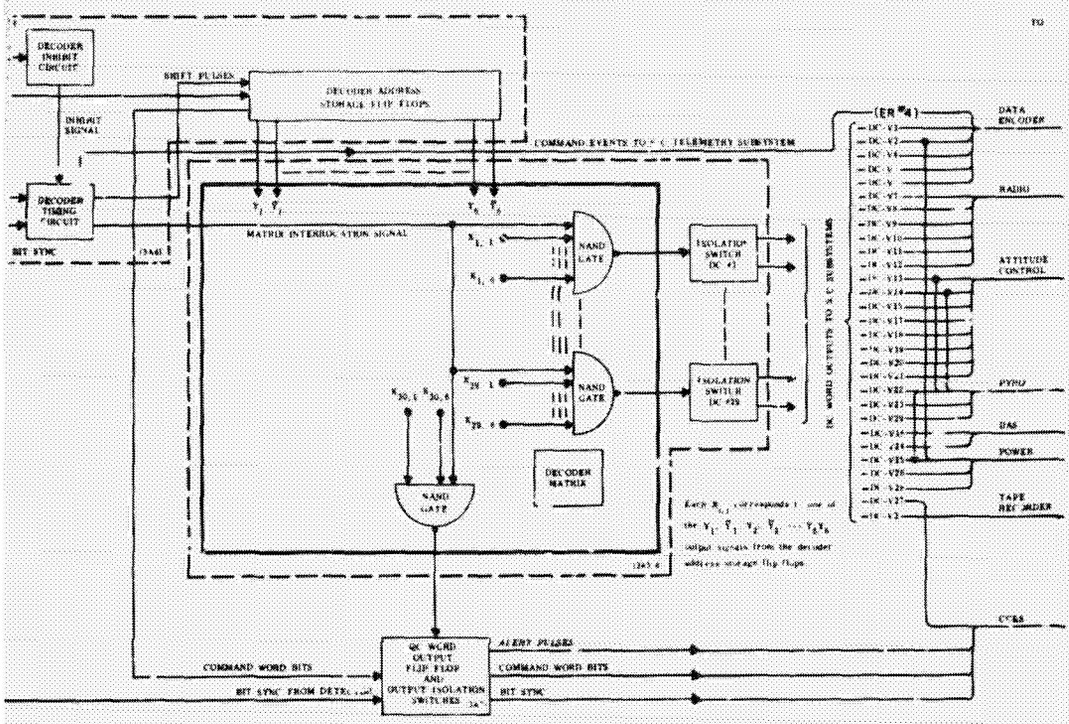


Fig. 18. Command subsystem

Fig. 19. Command format



MARINER V COMMAND WORD FORMAT

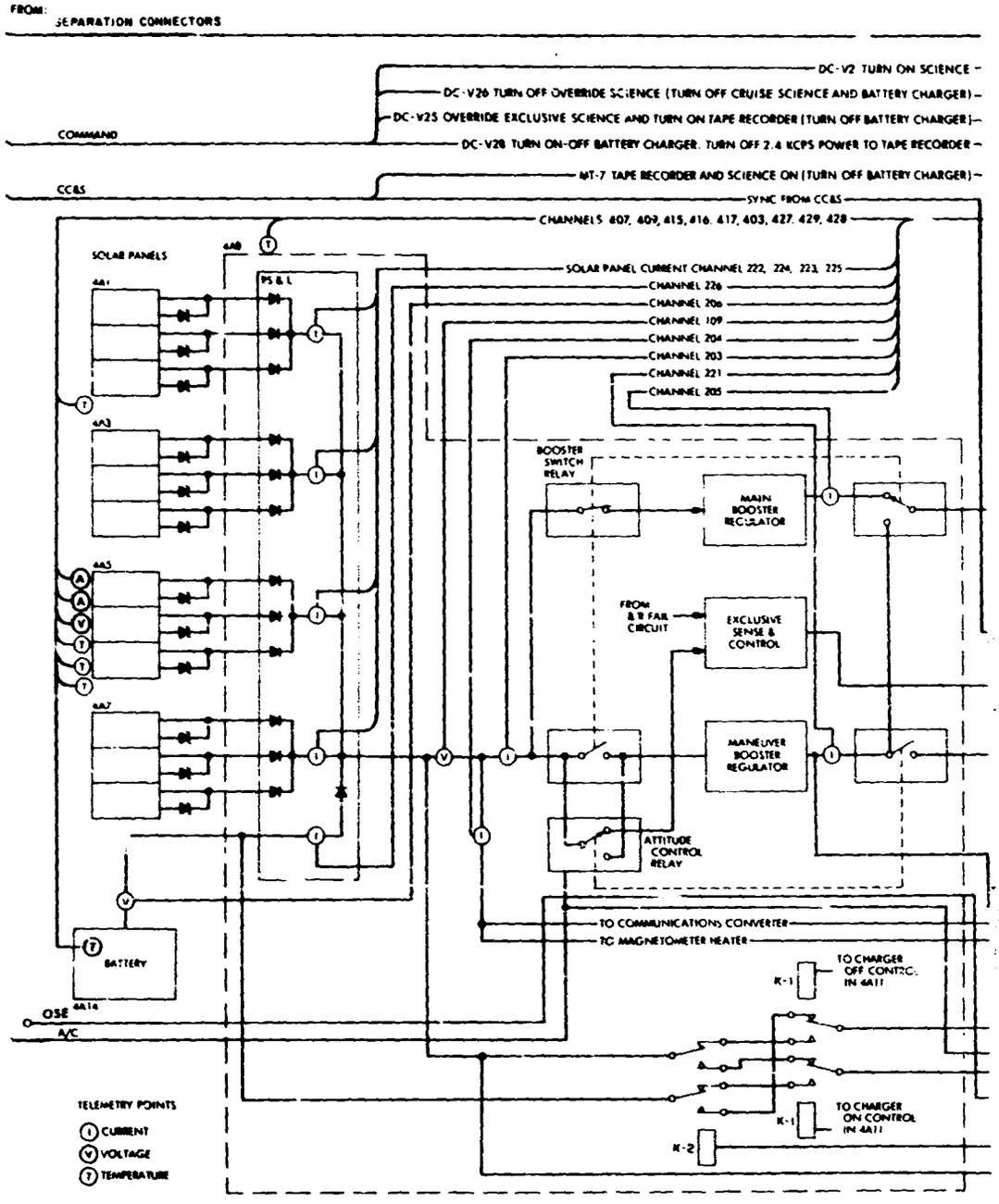
COMMAND BIT NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
COMMAND BIT IDENTIFICATION	COM-MAND DECODER START			COMMAND ADDRESS						ADDRESS PARITY See Note 1		BITS 12-26 HAVE NO SIGNIFICANCE IN DC'S. IN QC'S THEY FORM PART OF THE CC&S COMMAND. REFER TO QUANTITATIVE COMMAND FORMAT														
COMMAND BIT VALUE	1	1	0	VARIABLE								"ZERO" FOR DC'S; VARIABLE FOR QC'S														

QUANTITATIVE COMMAND (QC) FORMAT

COMMAND BIT NO.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
CC&S COMMAND BIT NO.										1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
CC&S COMMAND BIT IDENTIFICATION										CC&S ADDRESS					See Note 3	TIME VALUE See Note 5											See Note 4
										See Note 2			Register Selector															
QC COMMAND BIT VALUES	PITCH TURN	1	1	0	0	1	1	0	0	0	1	1	1	0	ODD PARITY	VARIABLE											POLARITY
	ROLL TURN	1	1	0	0	1	1	0	0	0	0	0	0	1		VARIABLE											
	MOTOR BURN	1	1	0	0	1	1	0	0	0	1	0	1	1		VARIABLE											

NOTES:

1. COMMAND BITS 10 AND 11 ARE ADJUSTED TO ENSURE AGAINST SINGLE BIT ERRORS CAUSING AN INCORRECT COMMAND WORD *OUTPUT*.
2. COMMAND BITS 9 THROUGH 11 (CC&S COMMAND BITS 1 THROUGH 3) ARE NOT USED QUANTITATIVELY BY CC&S BUT ARE USED TO REMAIN COMPATIBLE WITH PREVIOUSLY DESIGNED HARDWARE (*MARINER II*)
3. COMMAND BIT 14 (CC&S COMMAND BIT 6) IS ADJUSTED IN QC'S TO GIVE AN ODD NUMBER OF "ONE" BITS IN COMMAND BITS 9 *THROUGH 26* (CC&S BITS 1 THROUGH 18).
4. COMMAND BIT 26 (CC&S *COMMAND BIT 18*) *MUST BE A "ONE" TO PRODUCE A CLOCKWISE (POSITIVE)* SPACECRAFT ROTATION ABOUT THE SPECIFIED SPACECRAFT AXIS. A "ZERO" IN THIS BIT POSITION WILL RESULT IN A COUNTERCLOCKWISE (NEGATIVE) SPACECRAFT ROTATION ABOUT THE SPECIFIED SPACECRAFT AXIS. POLARITY BIT FOR MOTOR BURN COMMAND IS ALWAYS "ONE."
5. COMMAND BITS 15 THROUGH 25 (CC&S COMMAND BITS 7 THROUGH 17) ARE A PSEUDOBINARY CODE REPRESENTATION OF THE TURN OR MOTOR BURN DURATION.


FROM:
SEPARATION CONNECTORS
COMMAND
DC-V2 TURN ON SCIENCE
DC-V26 TURN OFF OVERRIDE SCIENCE (TURN OFF CRUISE SCIENCE AND BATTERY CHARGER)
DC-V25 OVERRIDE EXCLUSIVE SCIENCE AND TURN ON TAPE RECORDER (TURN OFF BATTERY CHARGER)
DC-V28 TURN ON-OFF BATTERY CHARGER. TURN OFF 2.4 KCPS POWER TO TAPE RECORDER
CC&S
MT-7 TAPE RECORDER AND SCIENCE ON (TURN OFF BATTERY CHARGER)
SYNC FROM CC&S
CHANNELS 407, 409, 415, 416, 417, 403, 427, 429, 428
SOLAR PANELS
4A8
4A1
PS & L
SOLAR PANEL CURRENT CHANNEL 222, 224, 223, 225
CHANNEL 226
CHANNEL 206
CHANNEL 109
CHANNEL 204
CHANNEL 203
CHANNEL 221
CHANNEL 205
4A3
4A5
4A7
BOOSTER SWITCH RELAY
MAIN BOOSTER REGULATOR
FROM A & F FAIL CIRCUIT
EXCLUSIVE SENSE & CONTROL
MANEUVER BOOSTER REGULATOR
ATTITUDE CONTROL RELAY
TO COMMUNICATIONS CONVERTER
TO MAGNETOMETER HEATER
BATTERY
4A14
OSE
A/C
K-1
TO CHARGER OFF CONTRC. IN 4A11
K-1
TO CHARGER ON CONTROL IN 4A11
K-2
TELEMETRY POINTS
CURRENT
VOLTAGE
TEMPERATURE

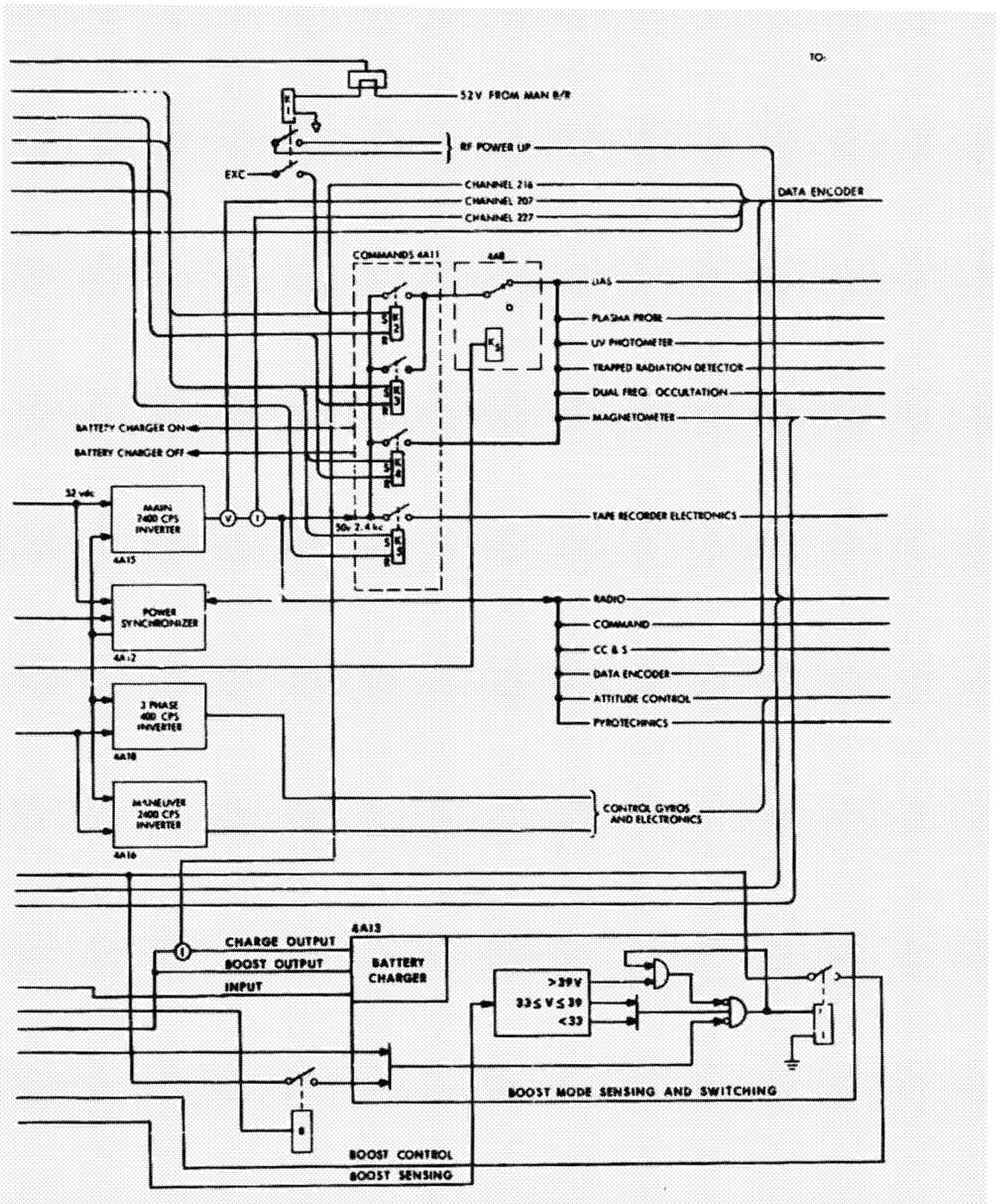
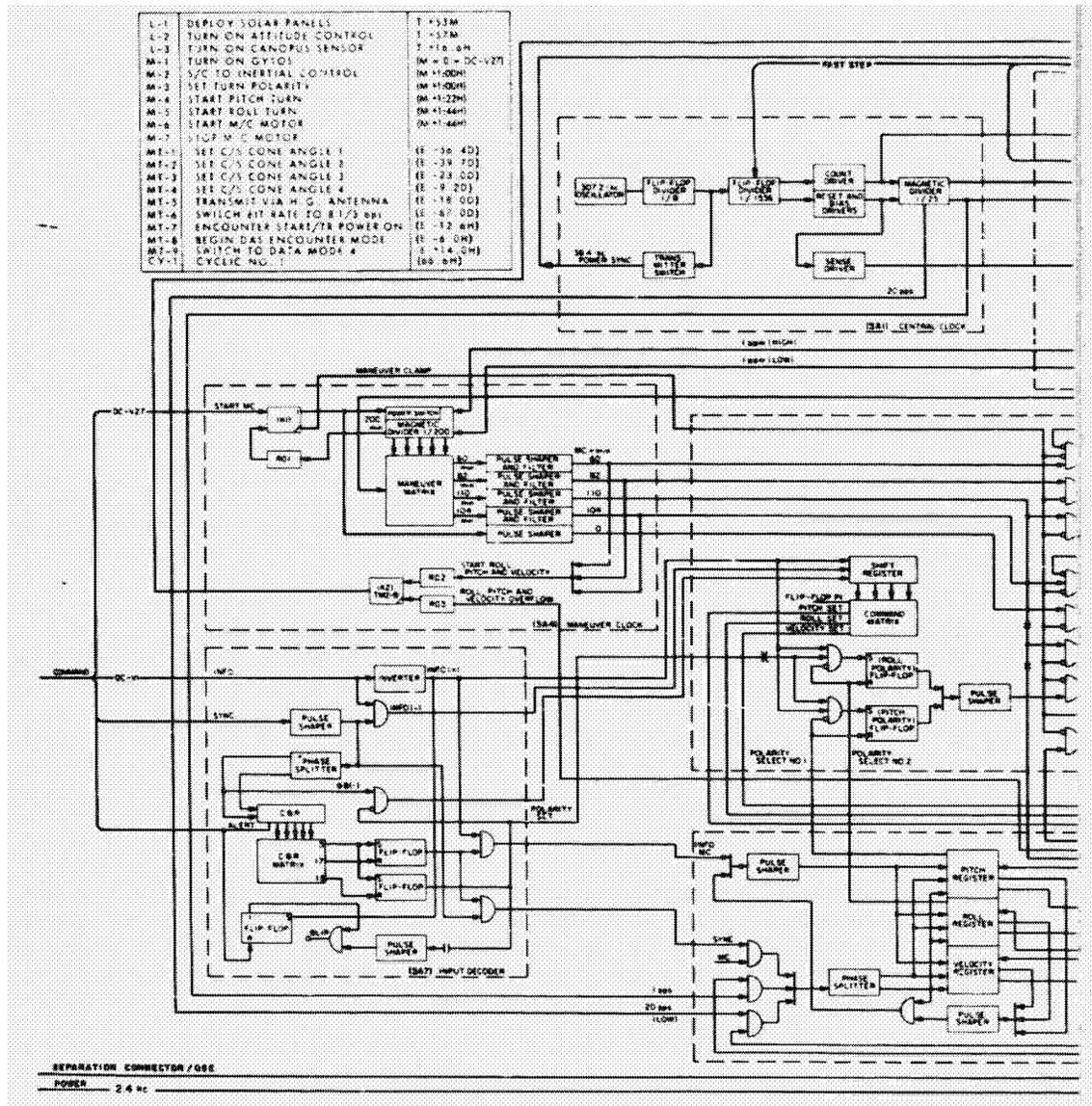


Fig. 20. Power subsystem


L-1 DEPLOY SOLAR PANELS T +53M
L-2 TURN ON ATTITUDE CONTROL T +52M
L-3 TURN ON CANOPUS SENSOR T +1h 6M
M-1 TURN ON GYROS (M = 0 = DC-V27)
M-2 S/C TO INERTIAL CONTROL (M +1:00H)
M-3 SET TURN POLARITY (M +1:00H)
M-4 START PITCH TURN (M +1:22H)
M-5 START ROLL TURN (M +1:44H)
M-6 START M/C MOTOR (M +1:44H)
M-7 STOP M/C MOTOR
MT-1 SET C/S CONE ANGLE 1 (E -36.40)
MT-2 SET C/S CONE ANGLE 2 (E -39.70)
MT-3 SET C/S CONE ANGLE 3 (E -23.00)
MT-4 SET C/S CONE ANGLE 4 (E -9.20)
MT-5 TRANSMIT VIA H. G. ANTENNA (E -18.00)
MT-6 SWITCH BIT RATE TO 81/3 bps (E -67.00)
MT-7 ENCOUNTER START/TR POWER ON (E -82.6M)
MT-8 BEGIN DAS ENCOUNTER MODE (E -6.0M)
MT-9 SWITCH TO DATA MODE 4 (E +14.0M)
CY-1 CYCLIC NO. 1 (86.6M)
FIRST STEP
1577 Hz OSCILLATOR
FLIP-FLOP DIVIDER 1/2
FLIP-FLOP DIVIDER 1/256
COUNT DRIVER
RESET AND BIAS DRIVERS
MAGNETIC DRIVER 1/25
SENSE DRIVER
TRANSMITTER SWITCH
20 pps
1541 CENTRAL CLOCK
1 pps (HIGH)
1 pps (LOW)
MANEUVER CLAMP
START M/C
DC +V27
INH
RDY
20C
MAGNETIC DRIVER 1/200
MANEUVER MATRIX
PULSE SHAPER AND FILTER
PULSE SHAPER
M/C + pps
M2
M1
M0
START ROLL PITCH AND VELOCITY
ROLL PITCH AND VELOCITY CHKP LOW
1546 MANEUVER CLOCK
SHIFT REGISTER
COMMAND MATRIX
ROLL POLARITY FLIP-FLOP
PITCH POLARITY FLIP-FLOP
POLARITY SELECT NO 1
POLARITY SELECT NO 2
PULSE SHAPER
COMMAND
DC +V
INH
INVERTER
SYNC
PULSE SHAPER
PHASE SPLITTER
C&R
C&R MATRIX
FLIP-FLOP
FLIP-FLOP
FLIP-FLOP
PULSE SHAPER
1547 INPUT DECODER
PITCH REGISTER
ROLL REGISTER
VELOCITY REGISTER
PHASE SPLITTER
PULSE SHAPER
20 pps (LOW)
SEPARATION CONNECTOR / 088
POWER 2.4 Hz

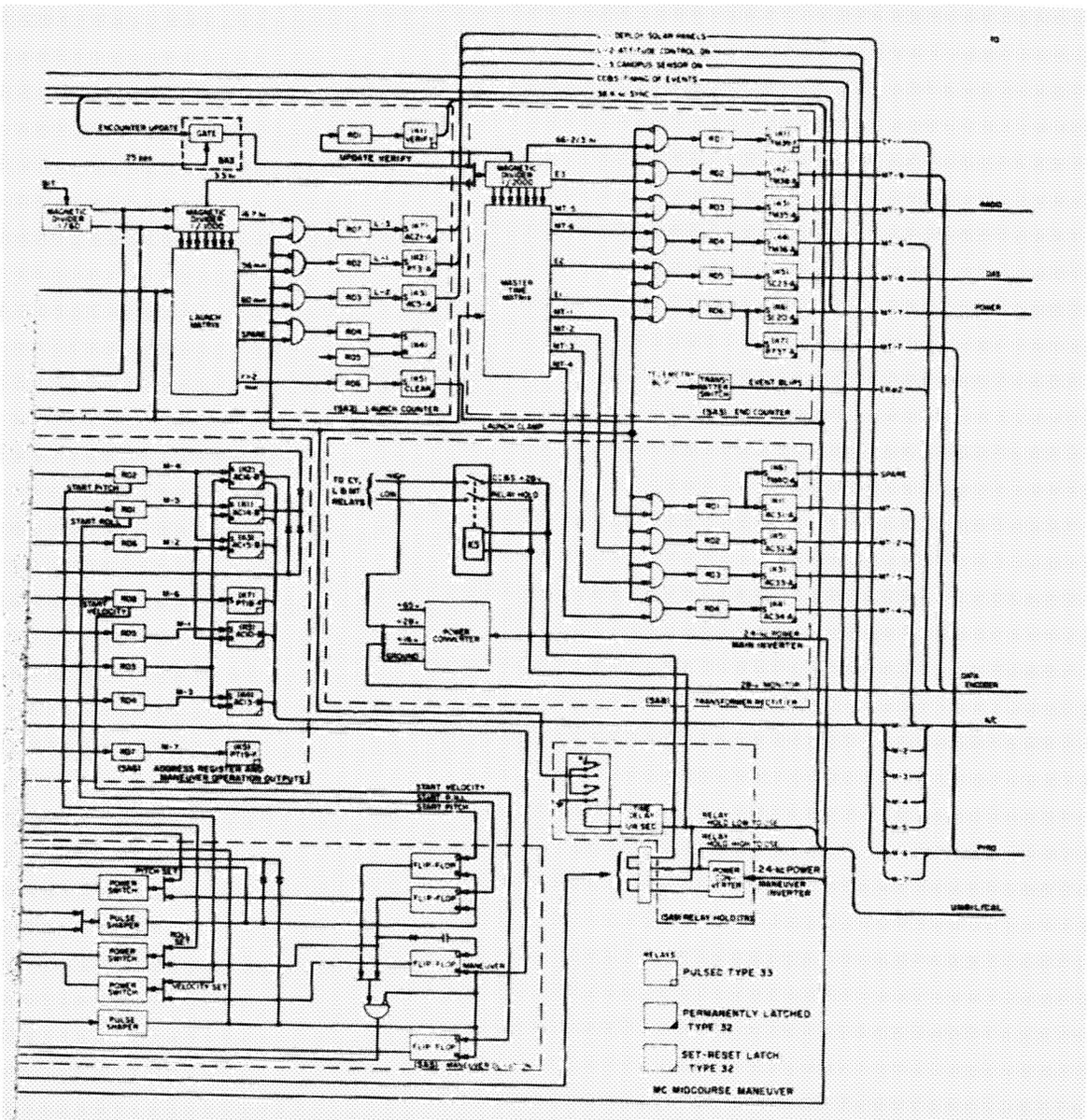


Fig. 21. CC&S subsystem

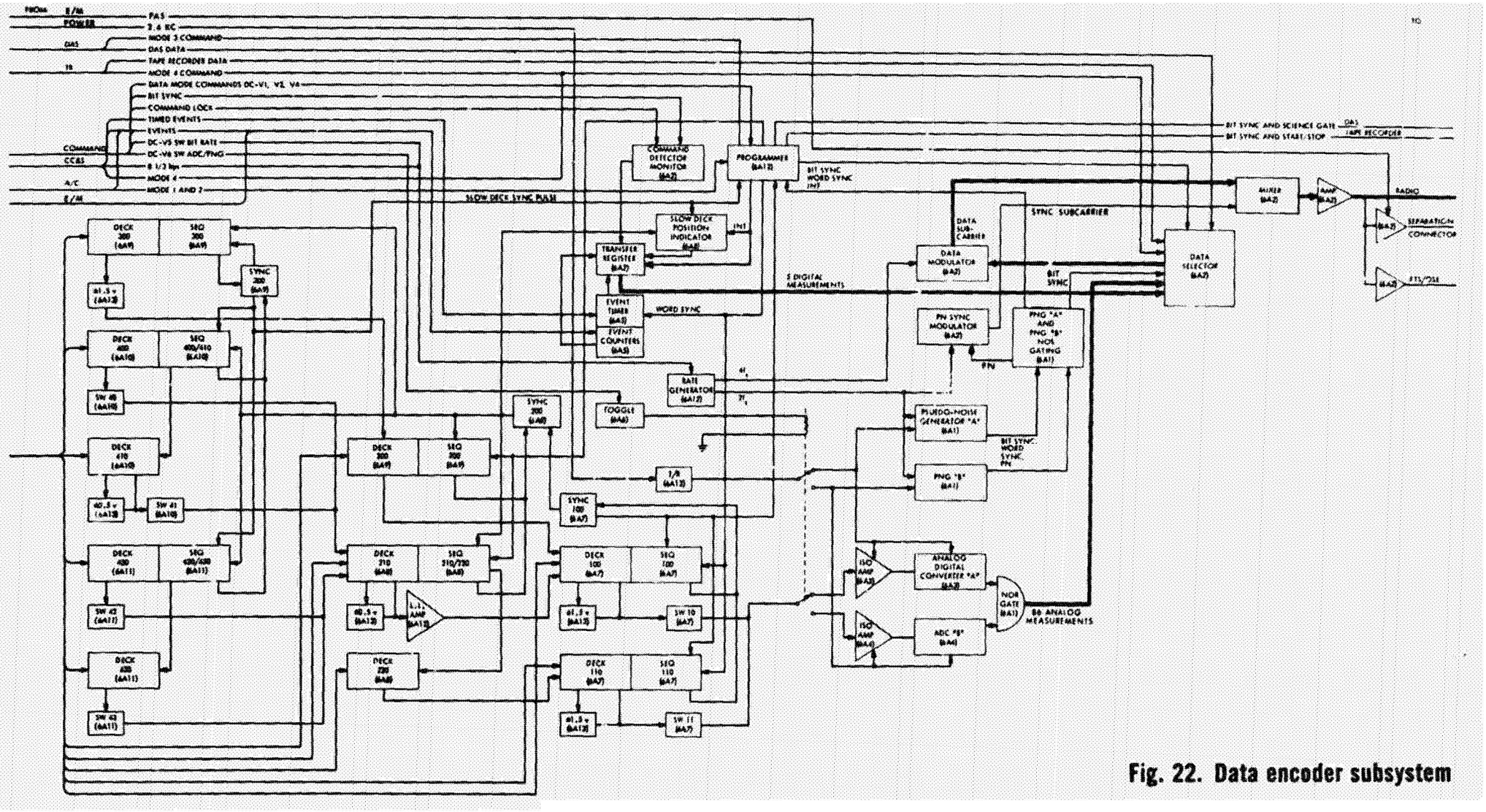


Fig. 22. Data encoder subsystem

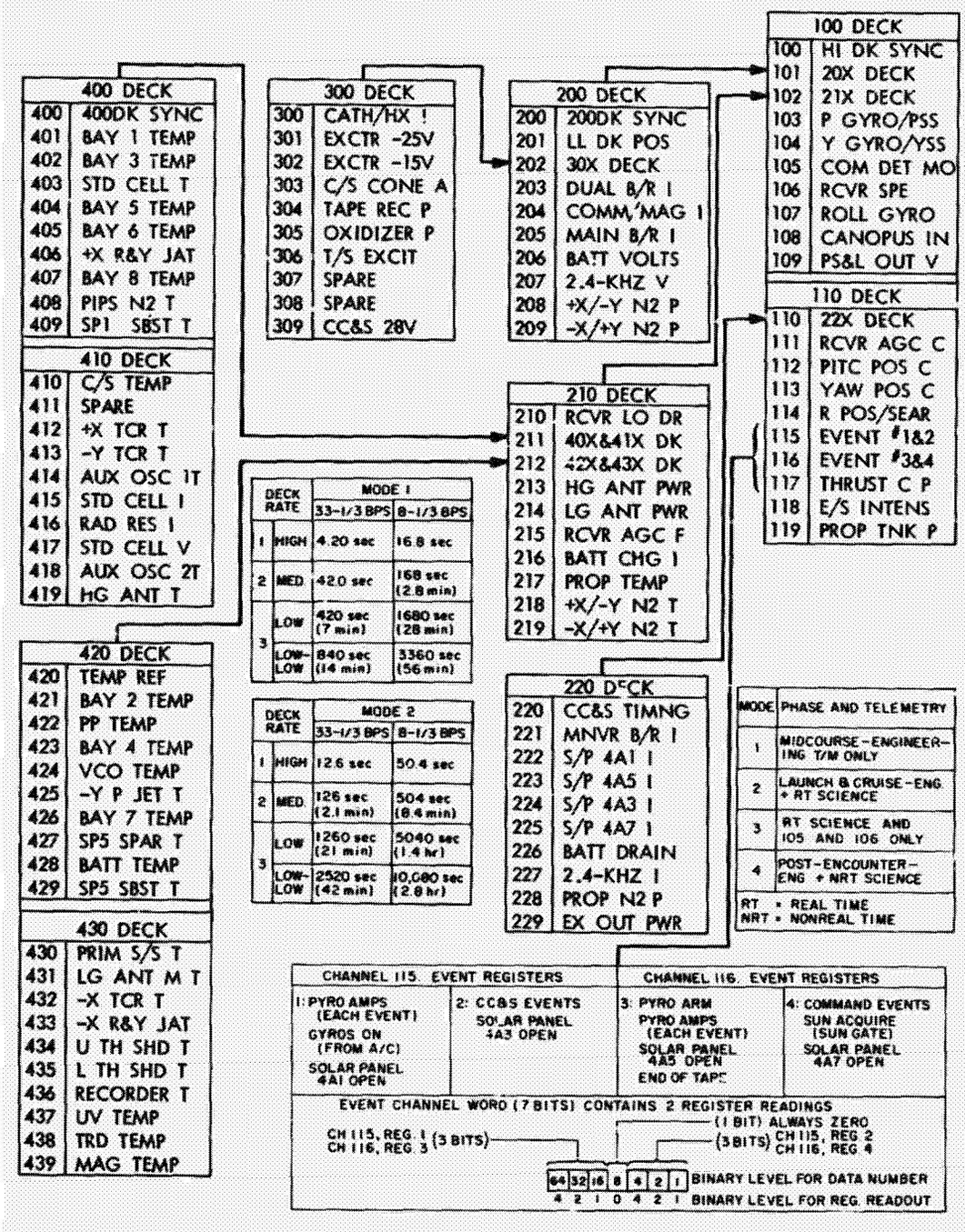
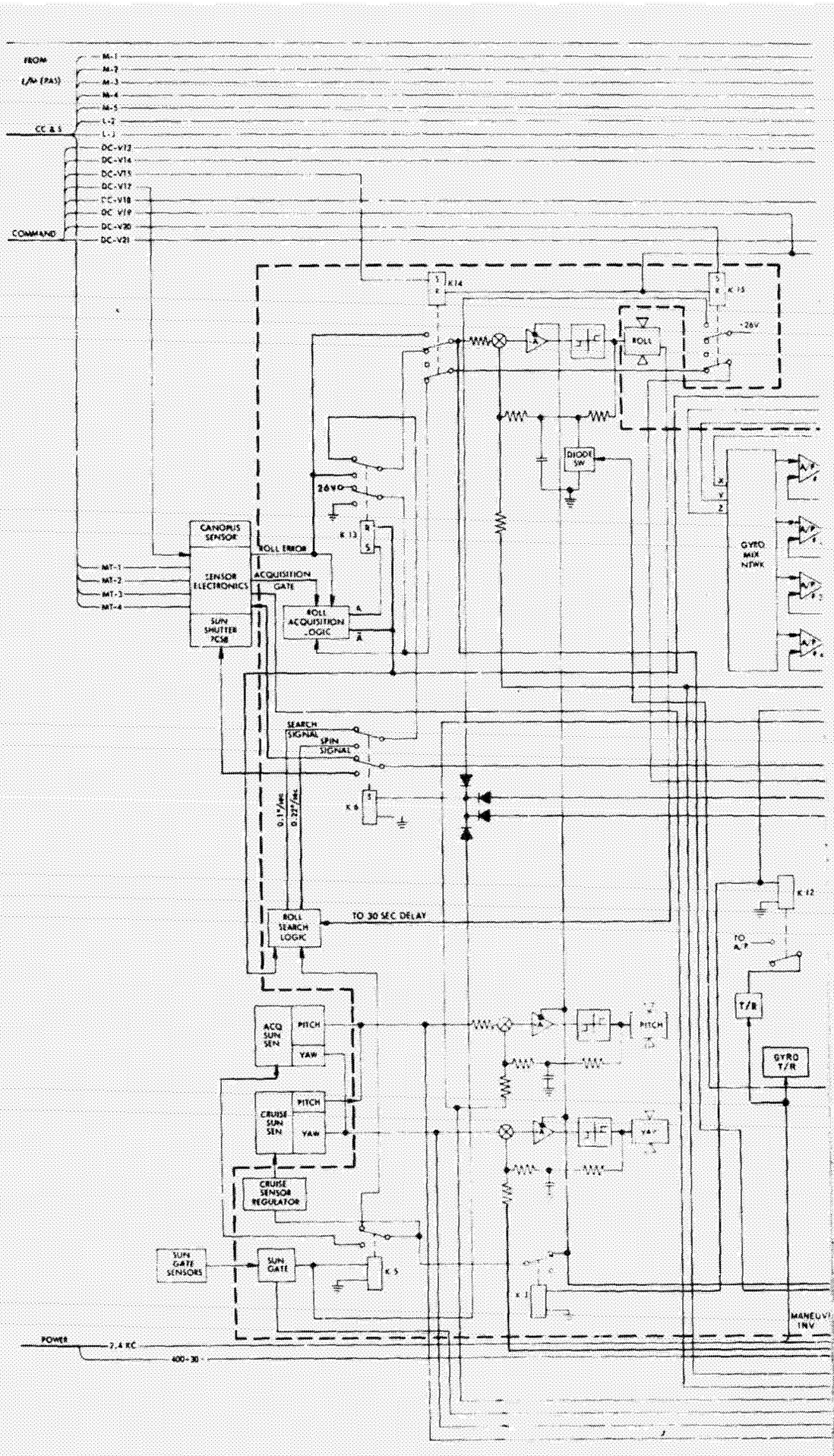


Fig. 23. Mariner V engineering telemetry commutation


FROM
L/M (PAS)
CC & S
COMMAND
M-1
M-2
M-3
M-4
M-5
L-2
L-3
DC-V12
DC-V14
DC-V15
DC-V17
DC-V18
DC-V19
DC-V20
DC-V21
K14
K15
-26V
ROLL
DIODE SW
26VO
K13
CANOPUS SENSOR
SENSOR ELECTRONICS
SUN SHUTTER
ROLL ERROR
ACQUISITION GATE
ROLL ACQUISITION LOGIC
MT-1
MT-2
MT-3
MT-4
GYRO MIX NTWK
SEARCH SIGNAL
SPIN SIGNAL
K6
0.1°/sec
0.22°/sec
ROLL SEARCH LOGIC
TO 30 SEC DELAY
K12
TO A/P
T/R
GYRO T/R
ACQ SUN SEN
PITCH
YAW
CRUISE SUN SEN
CRUISE SENSOR REGULATOR
SUN GATE SENSORS
SUN GATE
K5
K3
MANEUV INV
POWER
7.4 KC
400~30

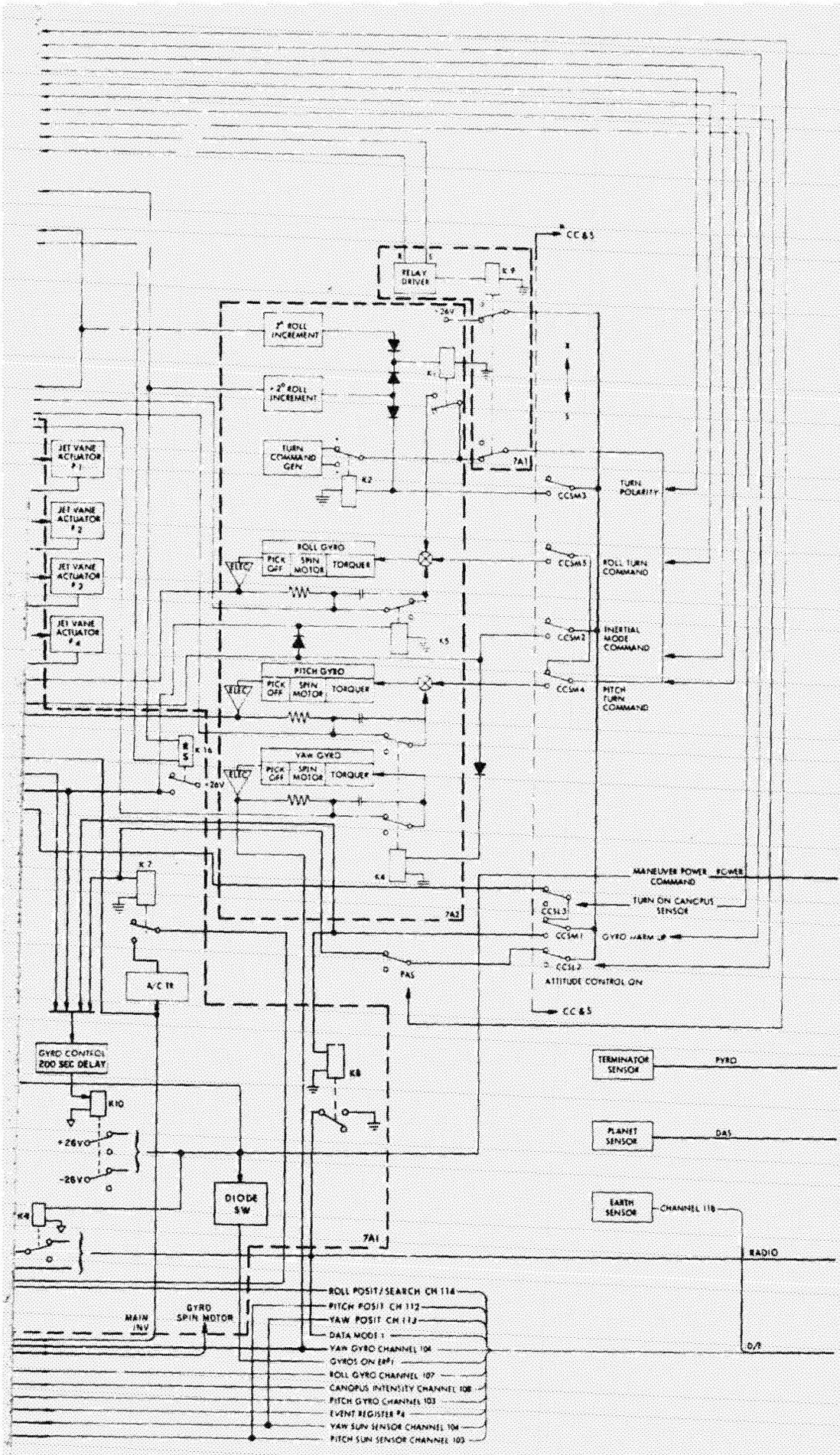


Fig. 24. Attitude control subsystem

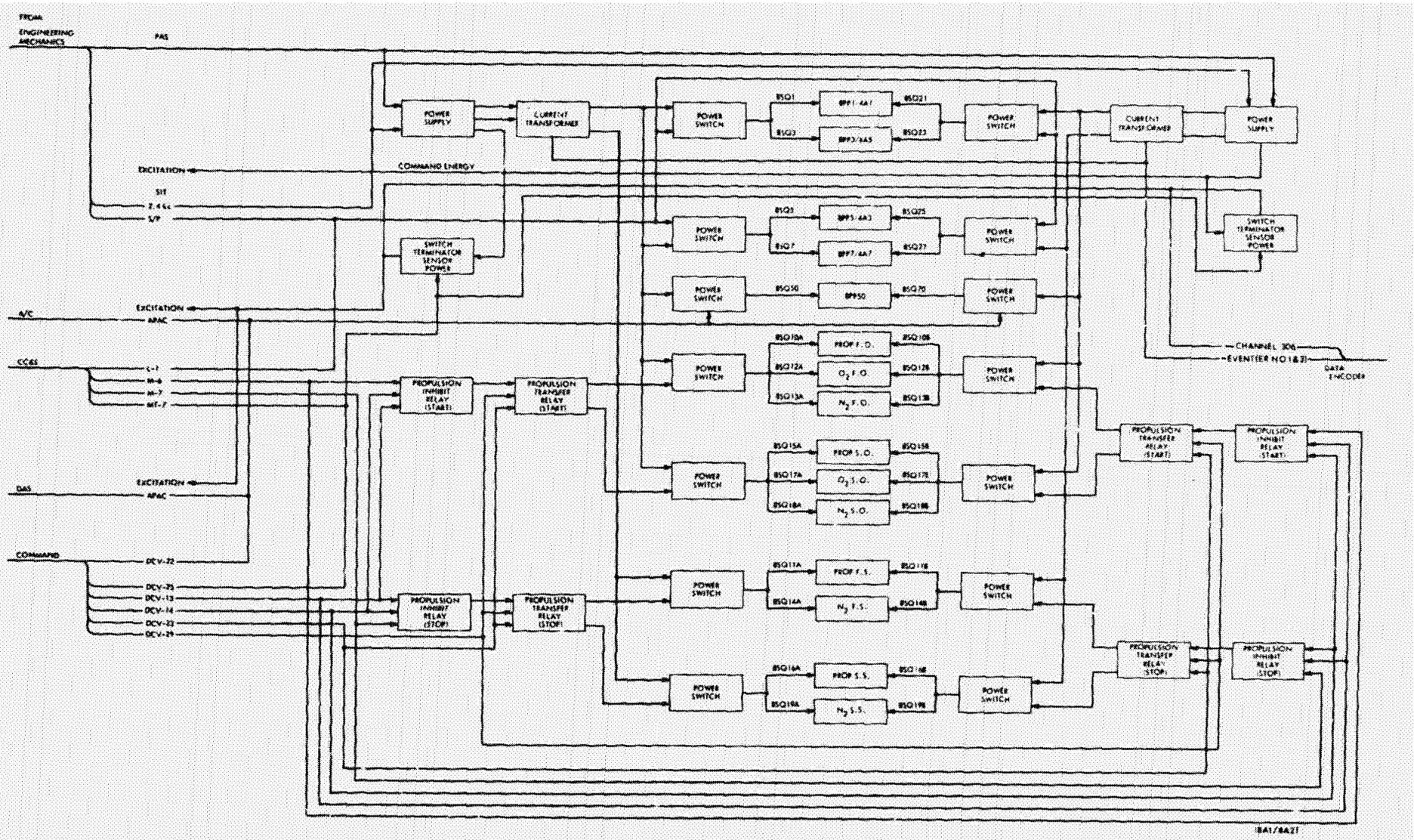


Fig. 25. Pyrotechnics subsystem

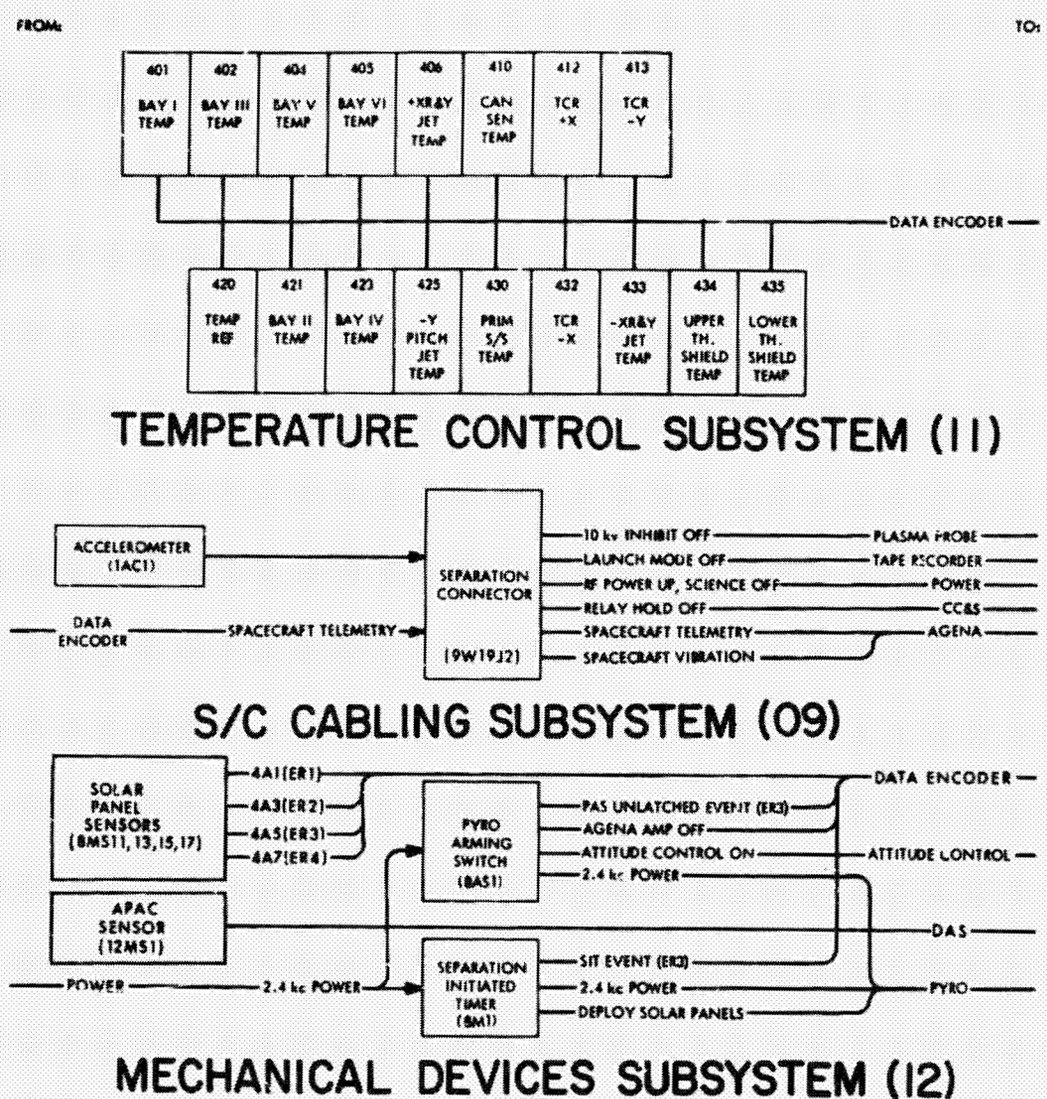


Fig. 26. Temperature control, cabling, and mechanical devices subsystems

COMPONENT SUMMARY

NO.	DESCRIPTION
1	ROCKET ENGINE
2	N_2 FILL VALVE, IGNITION CARTRIDGE
3	N_2 RESERVOIR, IGNITION CARTRIDGE
4	OXIDIZER VALVE, START NO. 1
5	OXIDIZER VALVE, START NO. 2
6	OXIDIZER RESERVOIR, IGNITION CARTRIDGE
7	CHECK VALVE
8	NITROGEN TANK
9	OXIDIZER FILL VALVE NO. 1 IGNITION CARTRIDGE
10	OXIDIZER FILL VALVE NO. 2 IGNITION CARTRIDGE
11	PROPELLANT VALVE, START NO. 1
12	PROPELLANT VALVE, START NO. 2
13	PROPELLANT VALVE, SHUTOFF NO. 1
14	PROPELLANT VALVE, SHUTOFF NO. 2
15	FILL VALVE, PROPELLANT
16	PROPELLANT BLADDER
17	PROPELLANT TANK
18	PREPRESSURIZATION VALVE, NITROGEN
19	FILL VALVE, NITROGEN TANK
20	PRESSURE REGULATOR, NITROGEN
21	NITROGEN FILTER
22	NITROGEN VALVE, START NO. 1
23	NITROGEN VALVE, START NO. 2
24	NITROGEN VALVE, SHUTOFF NO. 1
25	NITROGEN VALVE, SHUTOFF NO. 2

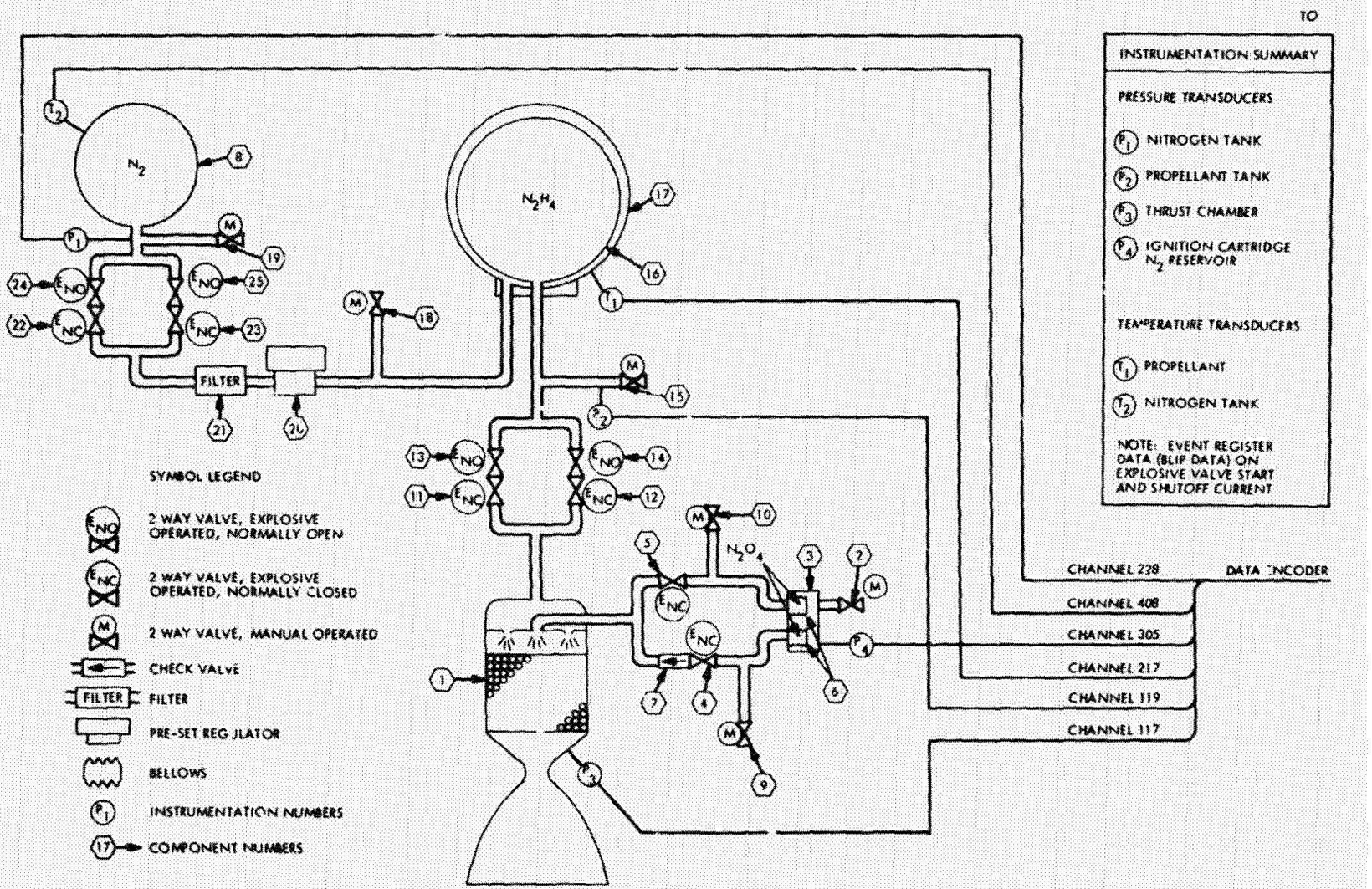


Fig. 27. Propulsion subsystem

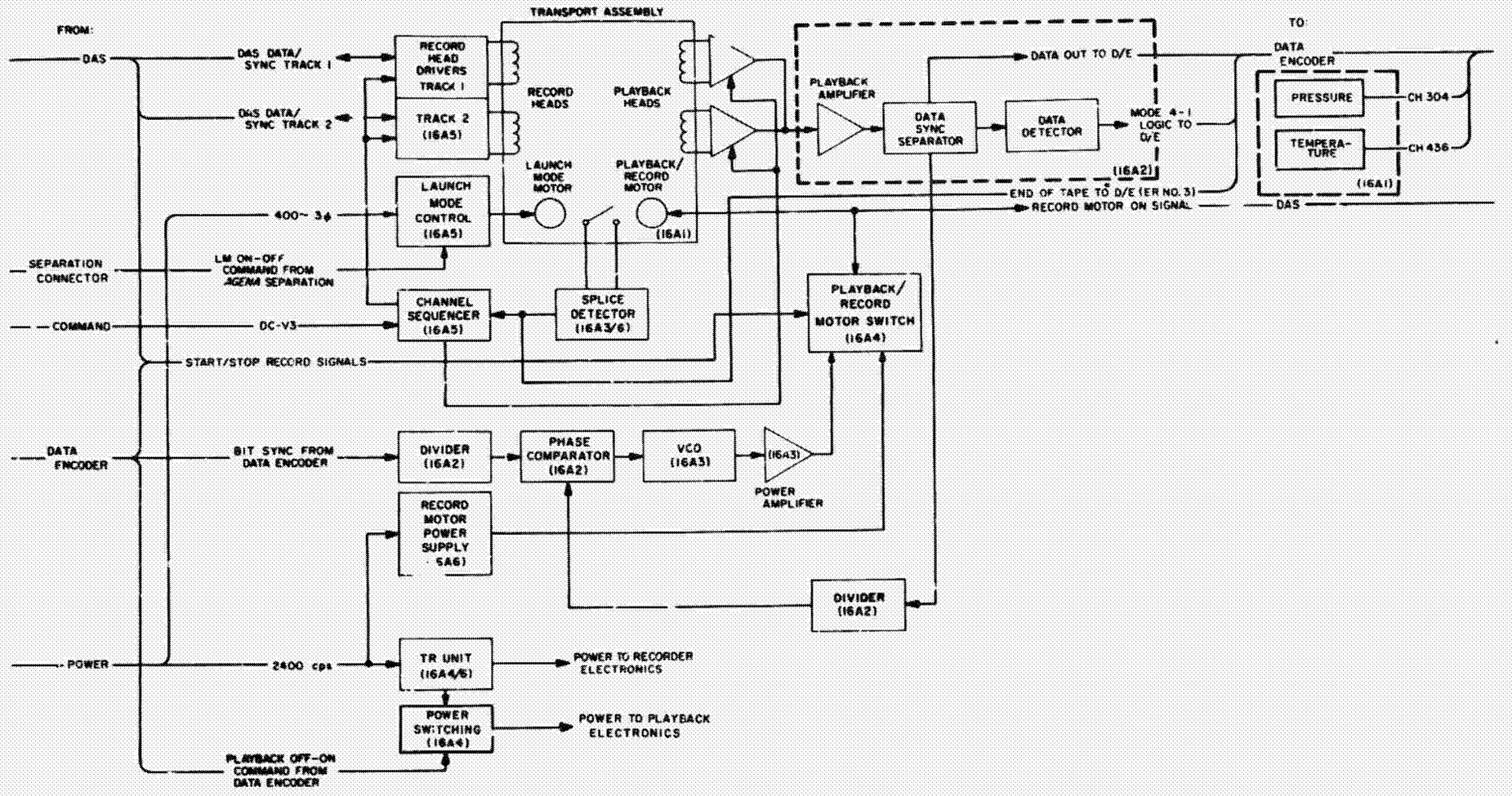
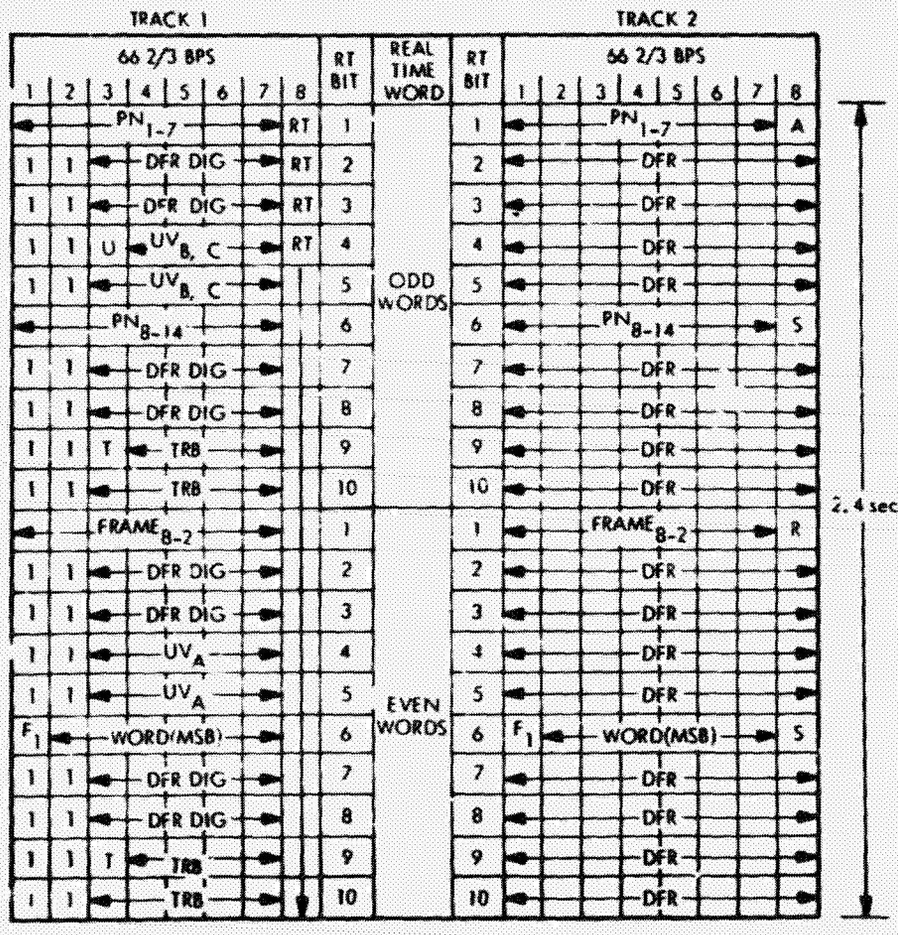


Fig. 28. Tape recorder subsystem



THE DATA FOR DFR, UV, AND TRA IS RECORDED MSB FIRST, LSB LAST

TAPE RECORDER FORMAT ABBREVIATIONS

PN_{1-7}	= BITS 1-7 OF 15-BIT PN SEQUENCE (0000111)
PN_{8-14}	= BITS 8-14 OF 15-BIT PN SEQUENCE (0110010)
$FRAME_{8-2}$	= FRAME COUNTER, LEAST SIGNIFICANT BITS 9-2
F_1	= FRAME COUNTER, LEAST SIGNIFICANT BIT 1
TRB	= TRAPPED RADIATION DETECTOR, DATA B
DFR DIG	= DFR DIGITAL DATA
UV_A	= UV, DATA A
RT	= REAL-TIME DATA
WORD (MSB)	= COARSE WORD COUNT:
U	= "1" IF $UV_{B, C}$ IS UV_C
T	= "1" IF TRB IS TRB; "0" IF TRB IS PL-5
K:	STATE CHANGE INDICATES LAST 8 DFR ANALOG WORDS WERE ACDE BCDE AND THAT THE NEXT 664 WORDS ARE IN THE BCDE SEQUENCE
DFR	= DFR ANALOG DATA
$UV_{B, C}$	= UV, DATA B OR C
S	= APAC STATUS BIT
A	= ONE IF DFR-A IS NEXT RECORDED WORD

RT WORDS	WORD (MSB)
1-7	100000
8-14	010000
15-21	001000
22-28	000100
29-35	000010
36-42	000001

Fig. 29. Tape recorder format

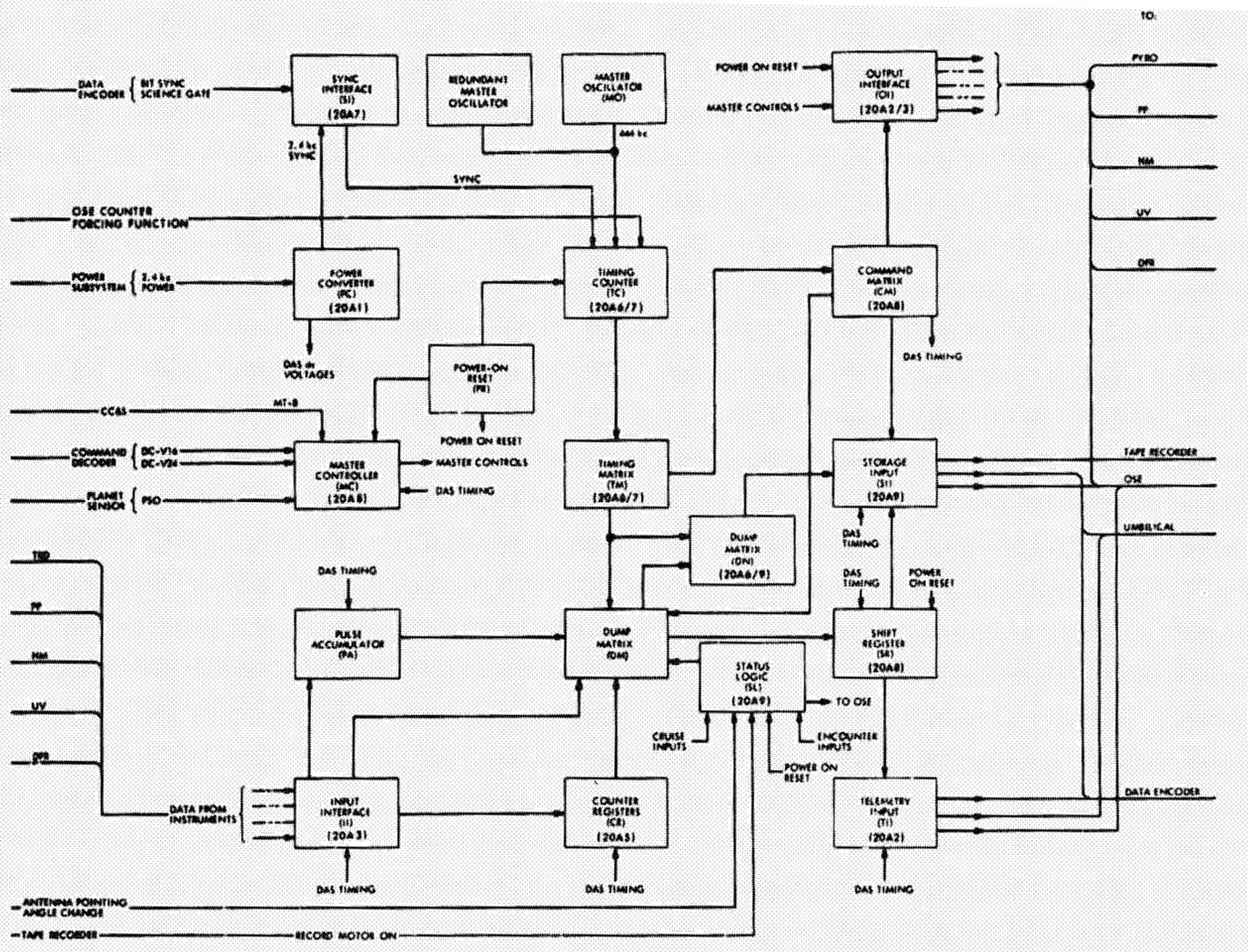


Fig. 30. Data automation subsystem

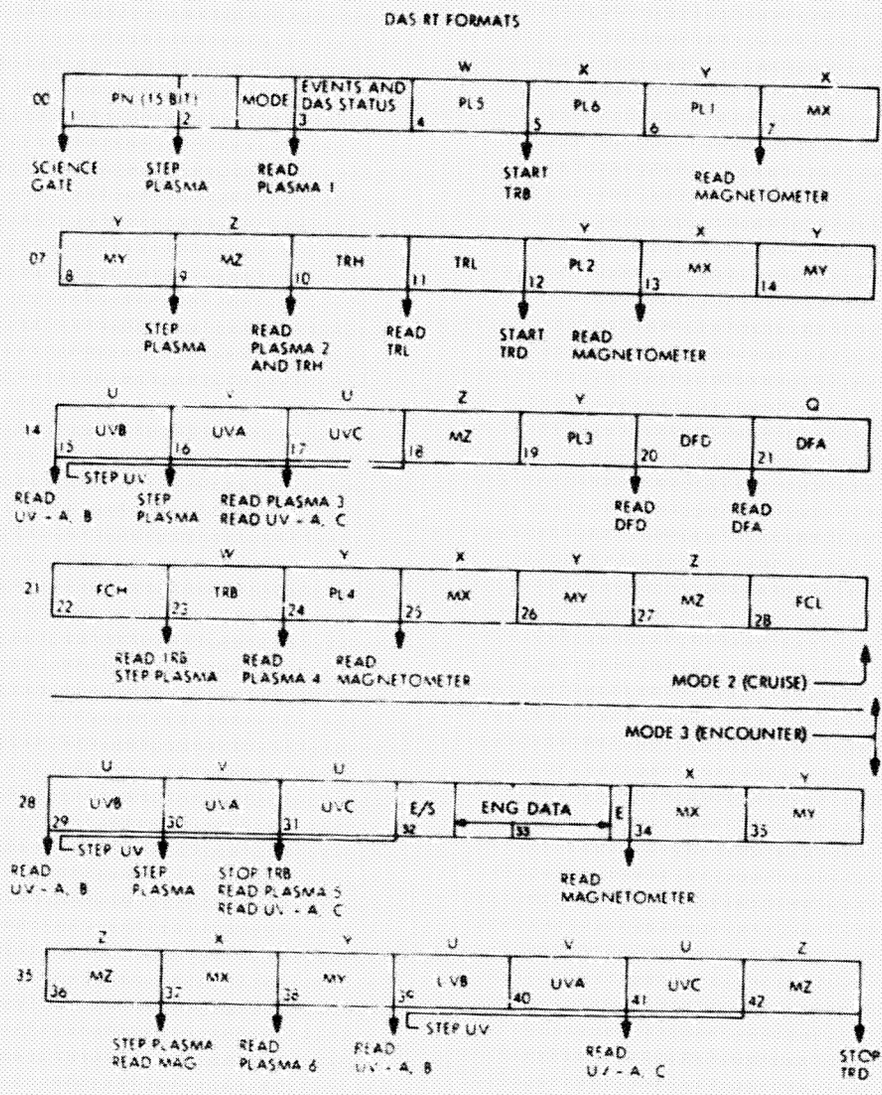


Fig. 31. DAS real-time format

BIT ABB	ENG WD SIGNF BIT	FUNCTION	BIT ABB	ENG WD SIGNF BIT	FUNCTION
PN		000 011 101 100 101	TRH		TRD HIGH
16	702/6	MT-B	TRL		TRD LOW
17	702/5	CL B ENABLE	UVB		UV TUBE B
18	702/4	DC-V16	201	728/3	DFR MOD Ø (EOF)
19	702/3	PSO	DFA		DFR ANALOG DATA
20	702/2	MODE 3	DFD		DFR DIGITAL DATA
21	702/1	MAG CAL 1 & 2	211	730/7	FCH/CL B(22 = 1/22 = 0)
22	703/7	MAG CAL 3 & 4	291	741/4	P/S EXCITATION
23	703/6	DAS PS HIGH	301	742/1	OSC A(0)/OSC B (1)
24	703/5	DAS PS LOW	311	744/5	START TAPE (EOF, PSO)
25	703/4	MAG IGNITION	312	744/4	STOP TAPE
26	703/3	RECORD MOTOR ON	313	744/3	TRACK 1 DATA
27	703/2	DFR CALIBRATE	314	744/2	TRACK 2 DATA
28	703/1	DFR DIG X-FER	315	744/1	PP MODE 3
31	704/5	APAC (F/C 224)	316	745	COM DET MO (7 BITS)
PL		PP DATA	323	746	RCVR SPE (7 BITS)
41	705/2	DFR STEP COMM (EOF)	381		SPARE (0)
51	707/6	STEP UV (EOF)	391	755/2	DC-V22 (APAC)
MX		MAG X-AXIS	401	757/6	UV CAL INHIBIT

Fig. 32. DAS real-time status bits

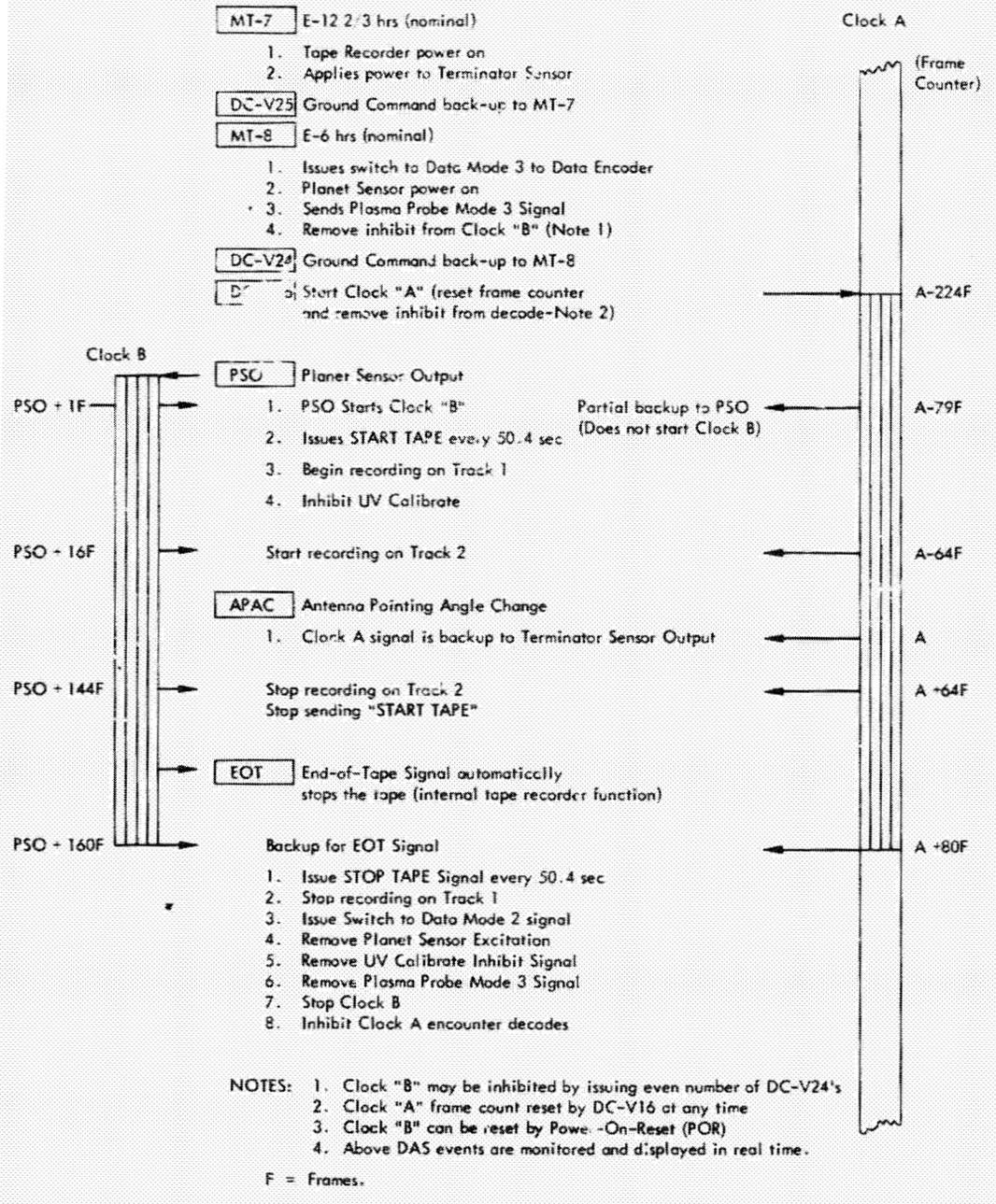


Fig. 33. DAS encounter sequence

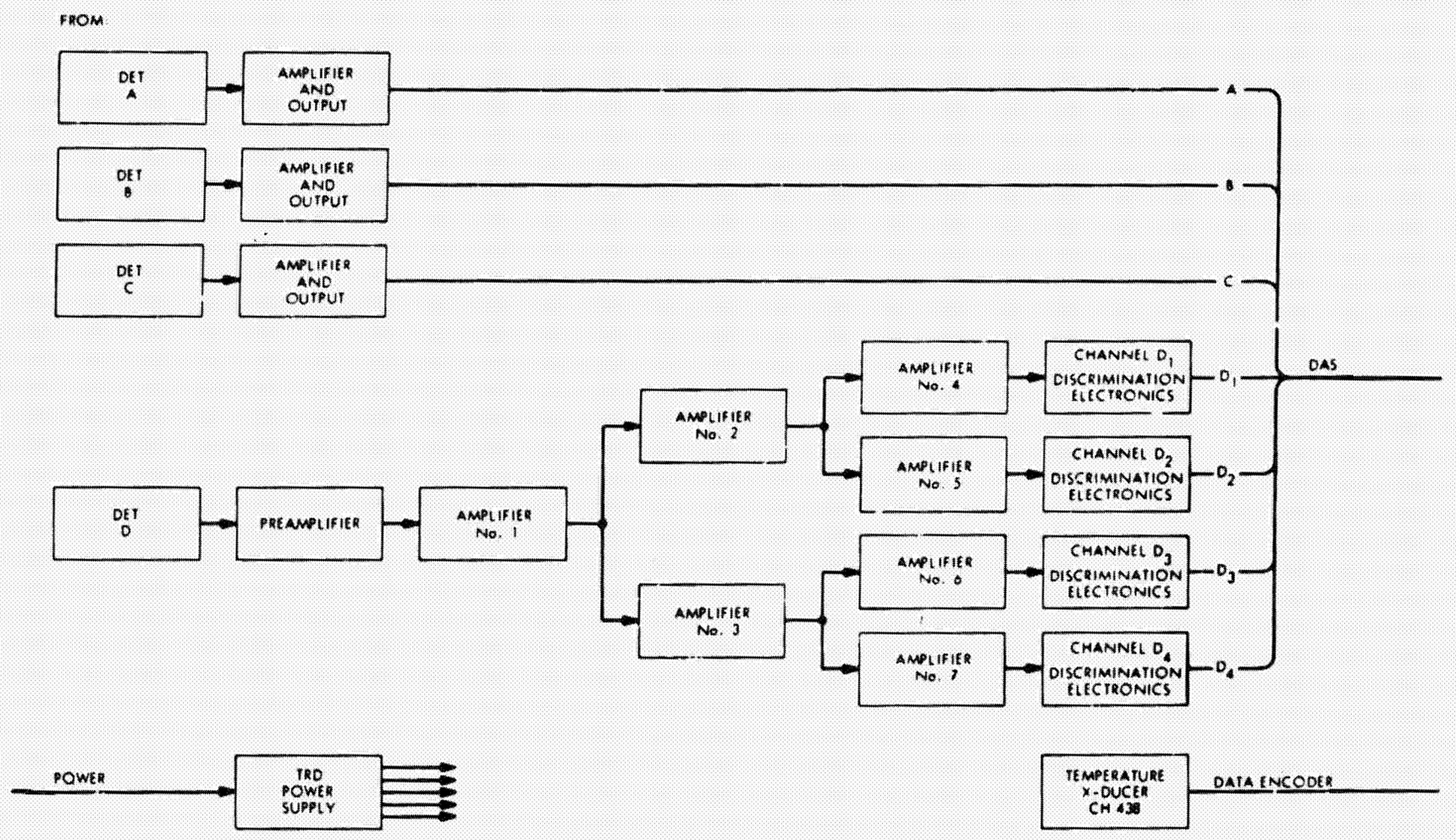


Fig. 34. Trapped radiation detector subsystem

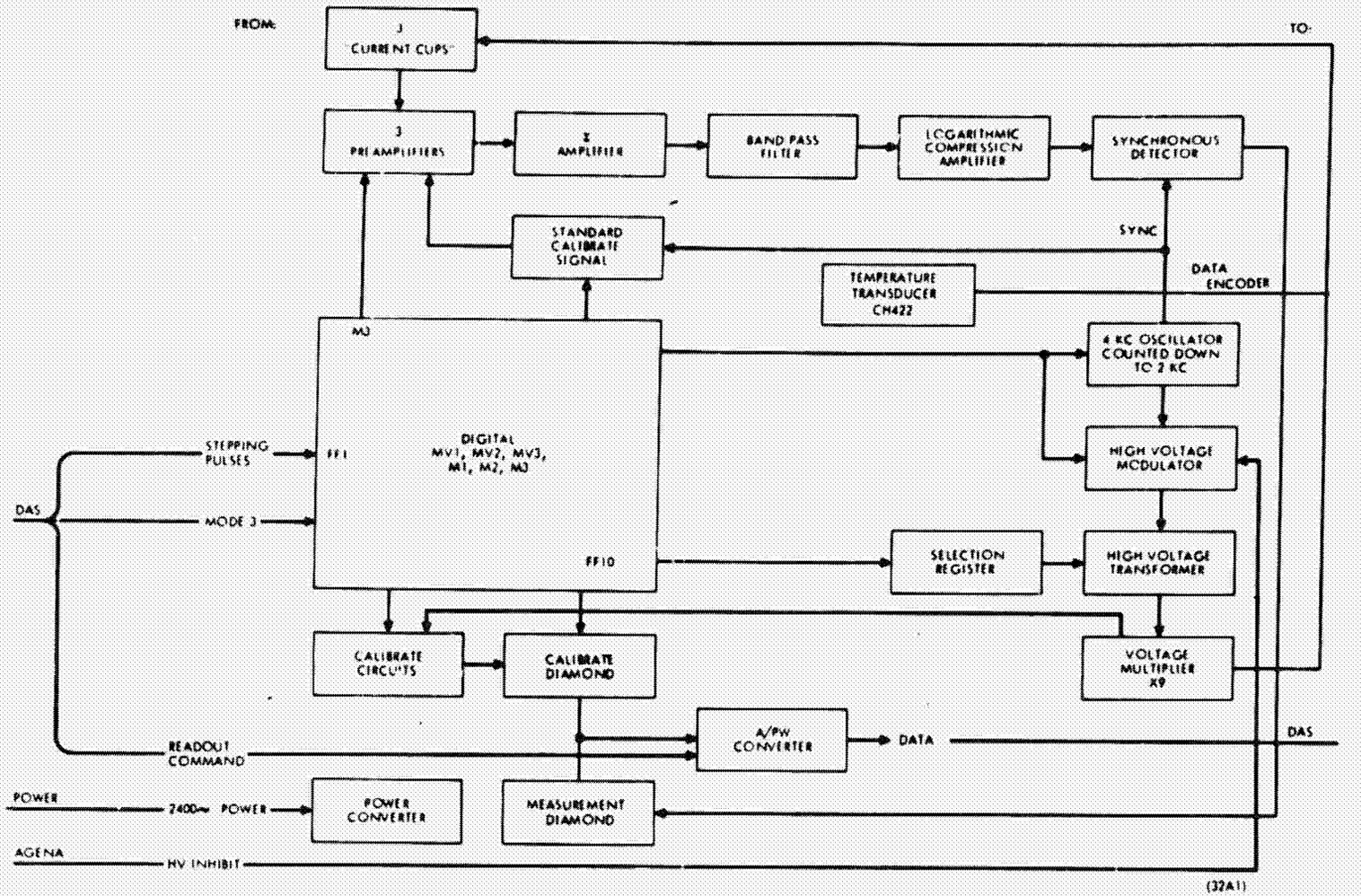
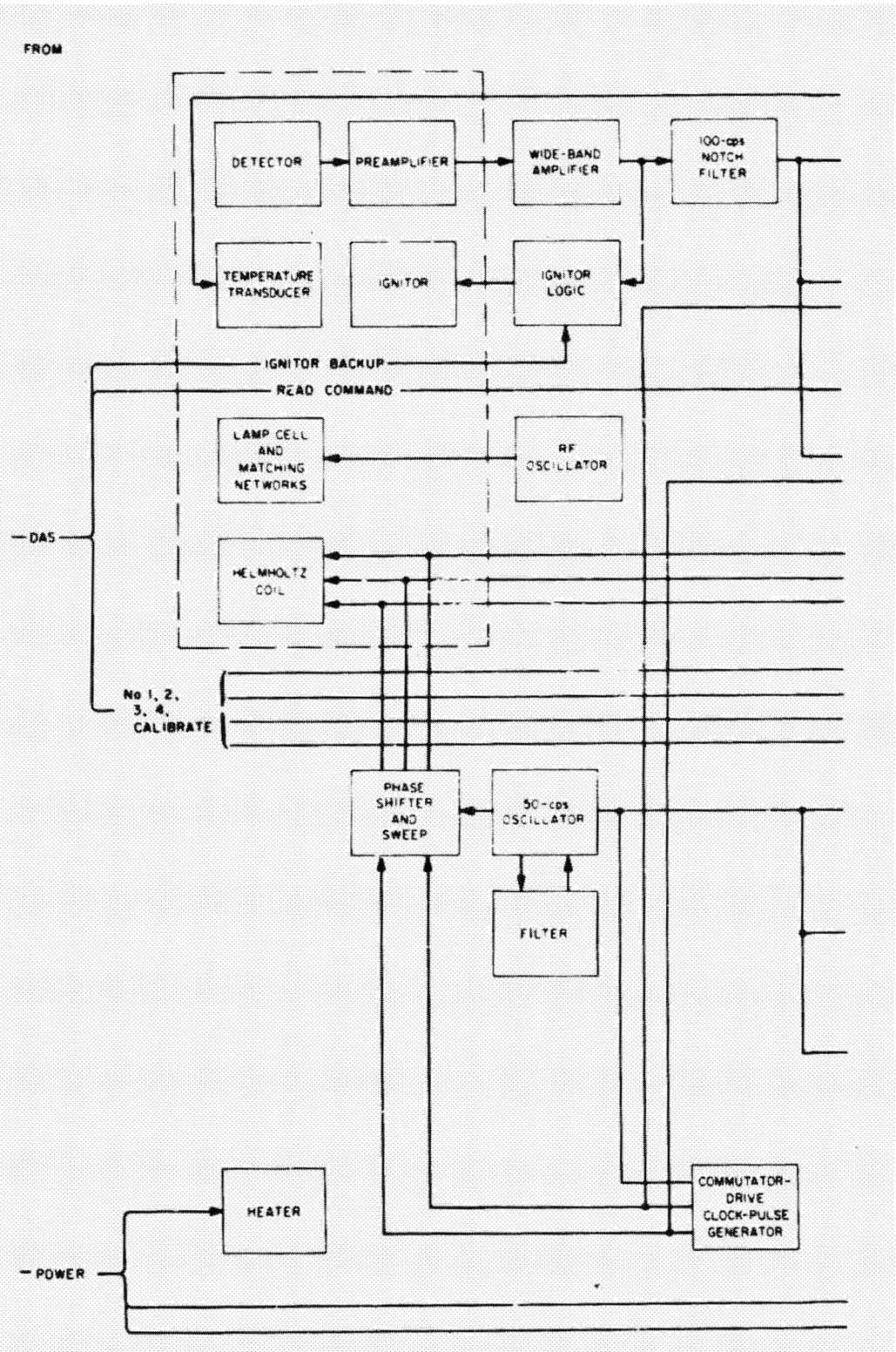


Fig. 35. Plasma probe subsystem


FROM
DETECTOR
PREAMPLIFIER
WIDE-BAND AMPLIFIER
100-cps NOTCH FILTER
TEMPERATURE TRANSDUCER
IGNITOR
IGNITOR LOGIC
IGNITOR BACKUP
READ COMMAND
LAMP CELL AND MATCHING NETWORKS
RF OSCILLATOR
DAS
HELMHOLTZ COIL
No 1, 2, 3, 4, CALIBRATE
PHASE SHIFTER AND SWEEP
50-cps OSCILLATOR
FILTER
COMMUTATOR-DRIVE CLOCK-PULSE GENERATOR
HEATER
POWER

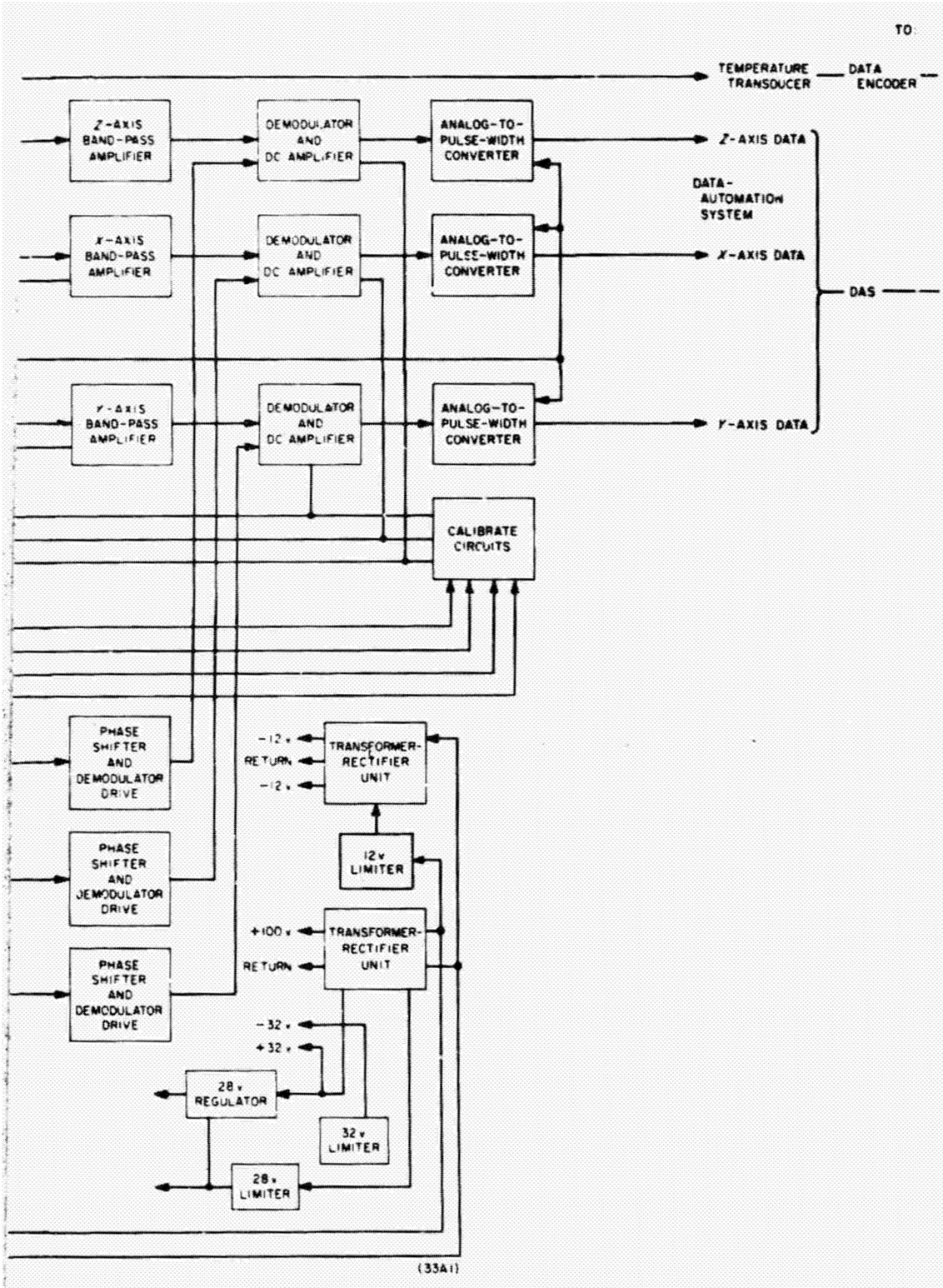
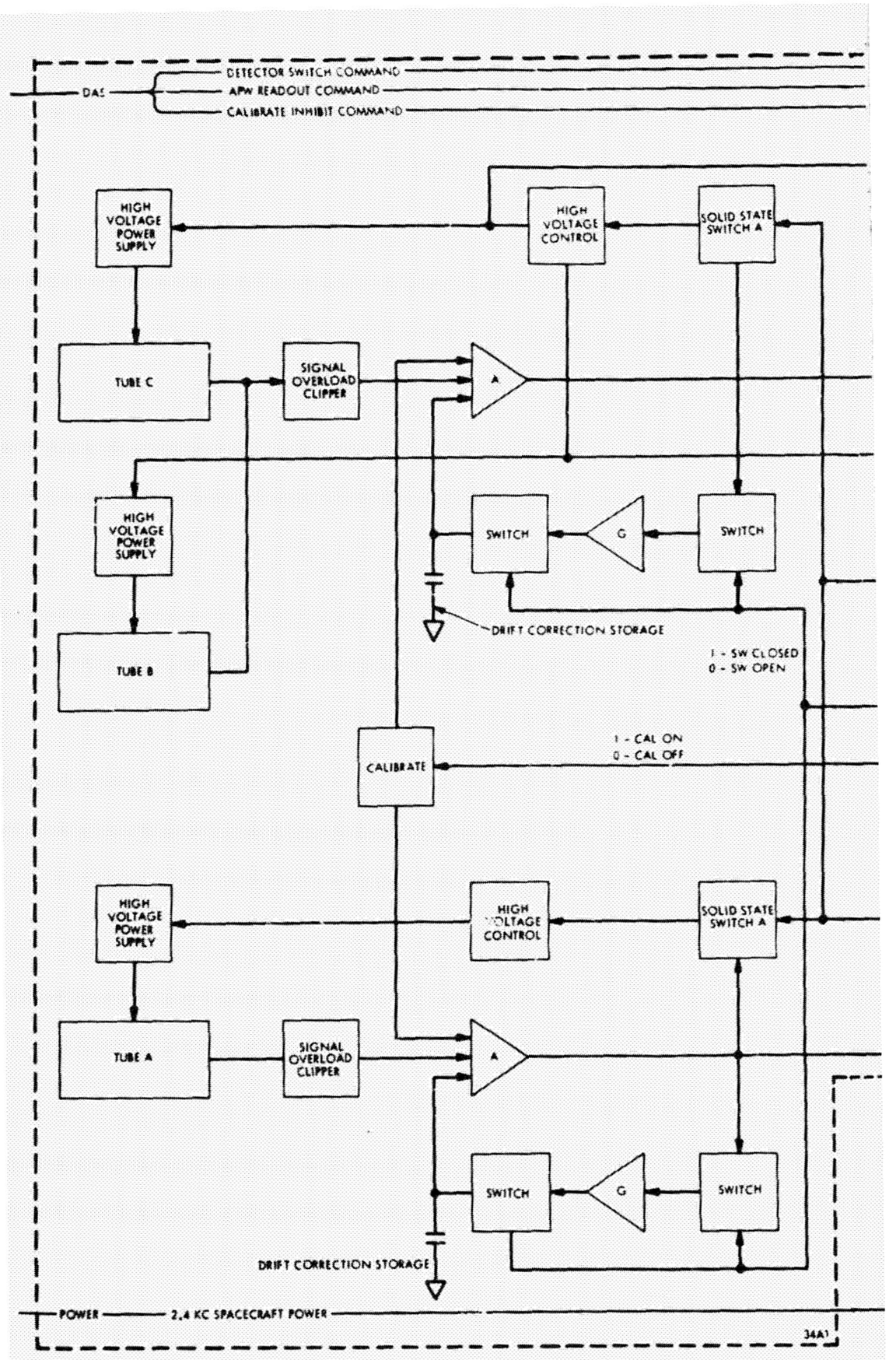


Fig. 36. Helium magnetometer subsystem


DAS
DETECTOR SWITCH COMMAND
APW READOUT COMMAND
CALIBRATE INHIBIT COMMAND
HIGH VOLTAGE POWER SUPPLY
HIGH VOLTAGE CONTROL
SOLID STATE SWITCH A
TUBE C
SIGNAL OVERLOAD CLIPPER
A
HIGH VOLTAGE POWER SUPPLY
SWITCH
G
SWITCH
DRIFT CORRECTION STORAGE
TUBE B
1 - SW CLOSED
0 - SW OPEN
CALIBRATE
1 - CAL ON
0 - CAL OFF
HIGH VOLTAGE POWER SUPPLY
HIGH VOLTAGE CONTROL
SOLID STATE SWITCH A
TUBE A
SIGNAL OVERLOAD CLIPPER
A
SWITCH
G
SWITCH
DRIFT CORRECTION STORAGE
POWER
2.4 KC SPACECRAFT POWER
34A1

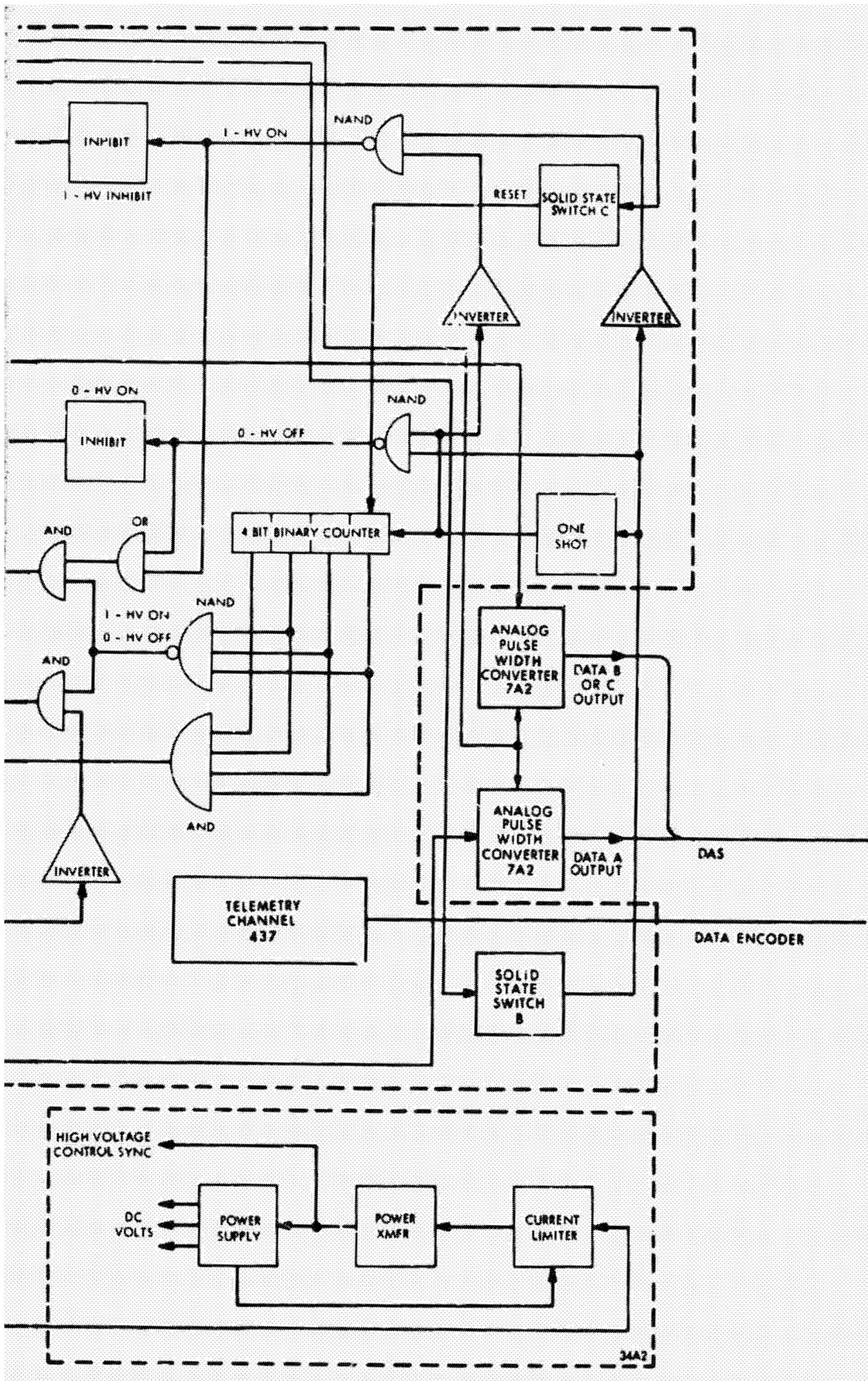
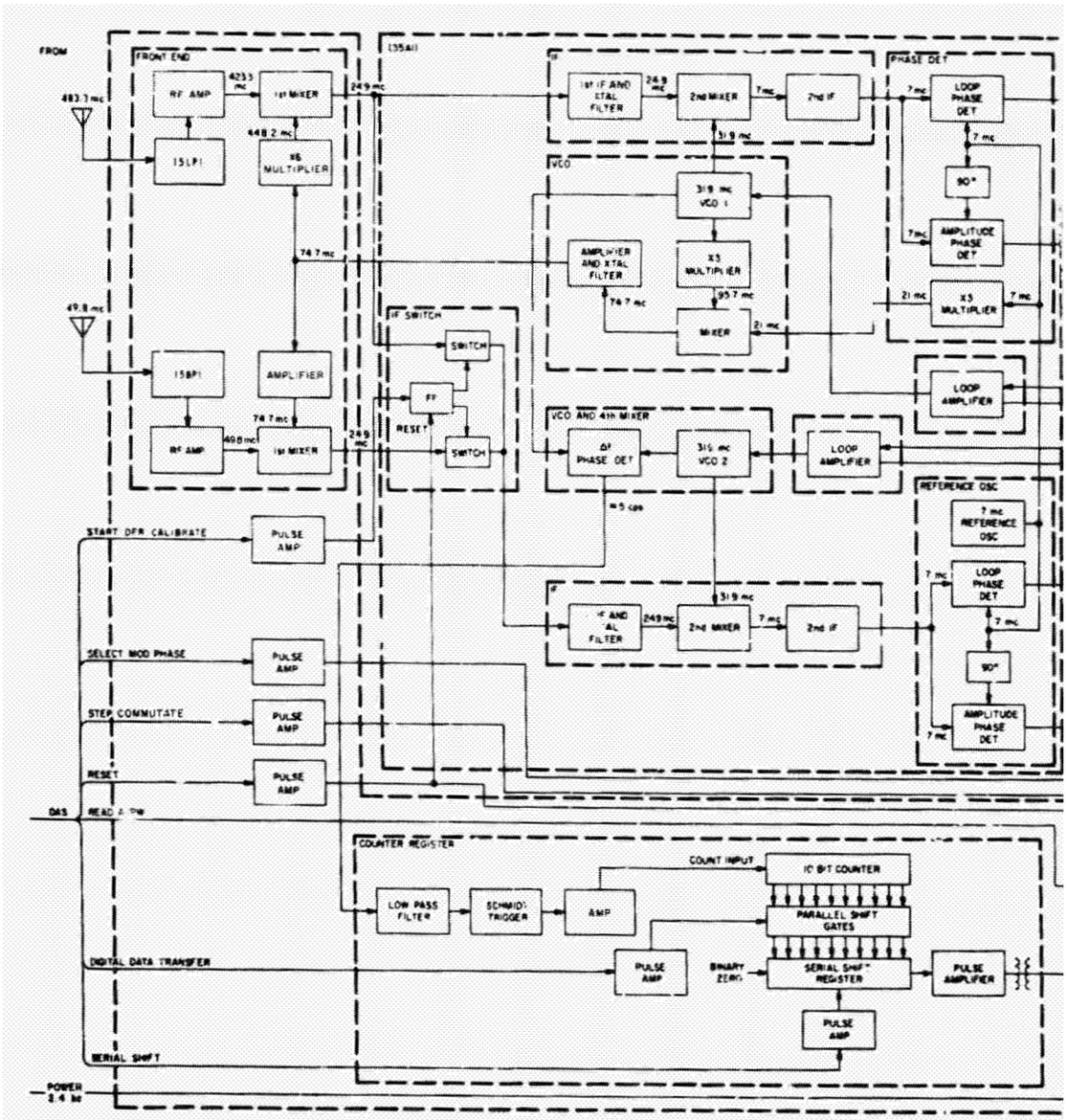


Fig. 37. Ultraviolet photometer subsystem


FROM
FRONT END
RF AMP
4233 mc
1st MIXER
249 mc
483.3 mc
448.2 mc
15LP1
X6 MULTIPLIER
74.7 mc
49.8 mc
15BP1
AMPLIFIER
74.7 mc
RF AMP
498 mc
1st MIXER
249 mc
(35AII)
IF
1st IF AND XTAL FILTER
249 mc
2nd MIXER
7 mc
2nd IF
31.9 mc
VCO
31.9 mc VCO 1
AMPLIFIER AND XTAL FILTER
X3 MULTIPLIER
95.7 mc
74.7 mc
MIXER
21 mc
IF SWITCH
SWITCH
FF
RESET
SWITCH
VCO AND 4th MIXER
Δf PHASE DET
31.5 mc VCO 2
LOOP AMPLIFIER
÷5 circ
IF
IF AND XTAL FILTER
249 mc
2nd MIXER
7 mc
2nd IF
31.9 mc
PHASE DET
7 mc
LOOP PHASE DET
7 mc
90°
7 mc
AMPLITUDE PHASE DET
21 mc
X3 MULTIPLIER
7 mc
LOOP AMPLIFIER
REFERENCE OSC
7 mc REFERENCE OSC
7 mc
LOOP PHASE DET
7 mc
90°
7 mc
AMPLITUDE PHASE DET
START DFR CALIBRATE
PULSE AMP
SELECT MOD PHASE
PULSE AMP
STEP COMMUTATE
PULSE AMP
RESET
PULSE AMP
DAS
READ A PW
COUNTER REGISTER
COUNT INPUT
10 BIT COUNTER
LOW PASS FILTER
SCHMIDT TRIGGER
AMP
PARALLEL SHIFT GATES
DIGITAL DATA TRANSFER
PULSE AMP
BINARY ZERO
SERIAL SHIFT REGISTER
PULSE AMPLIFIER
PULSE AMP
SERIAL SHIFT
POWER
-24 Vdc

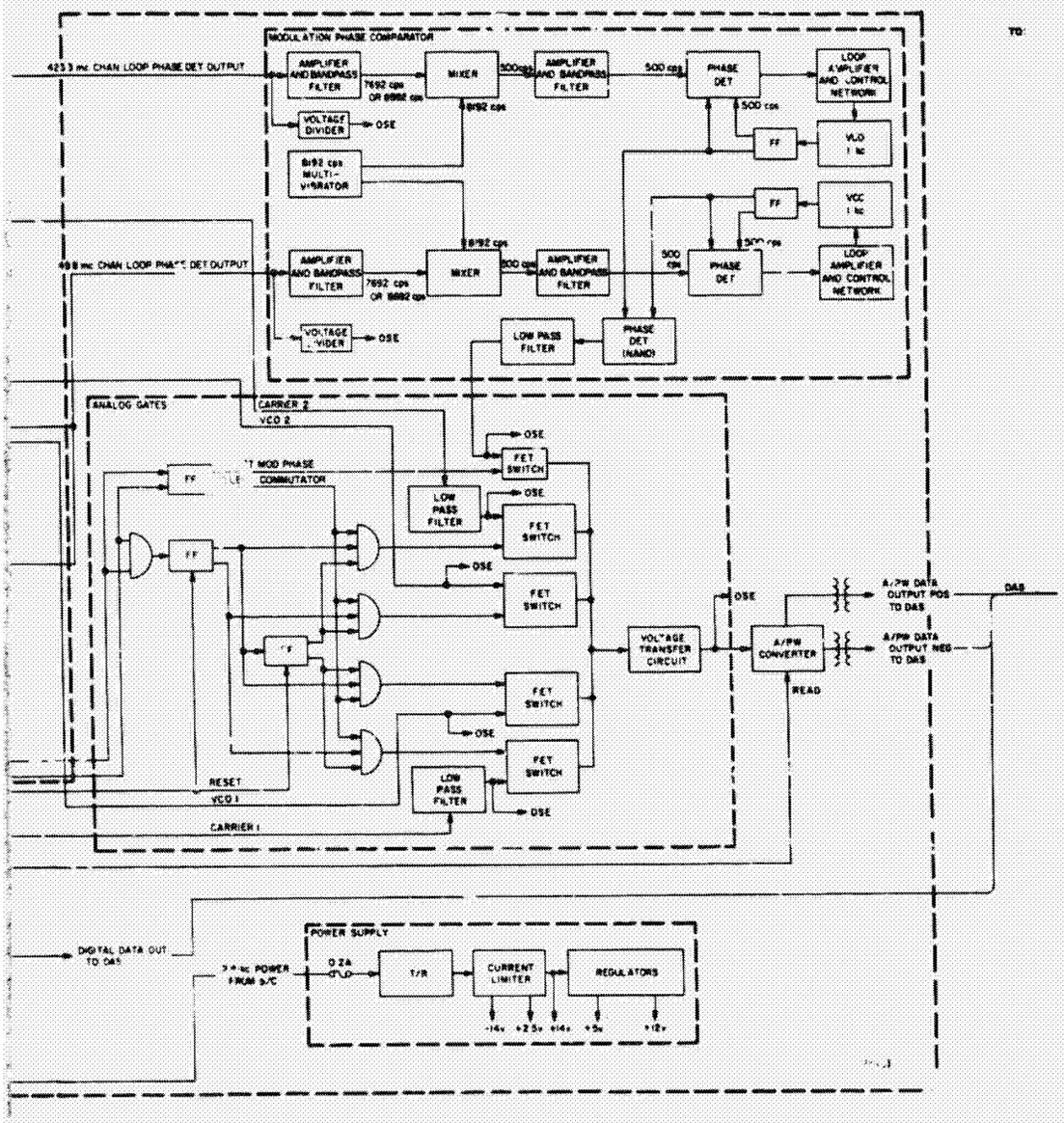


Fig. 38. Dual frequency receiver subsystem

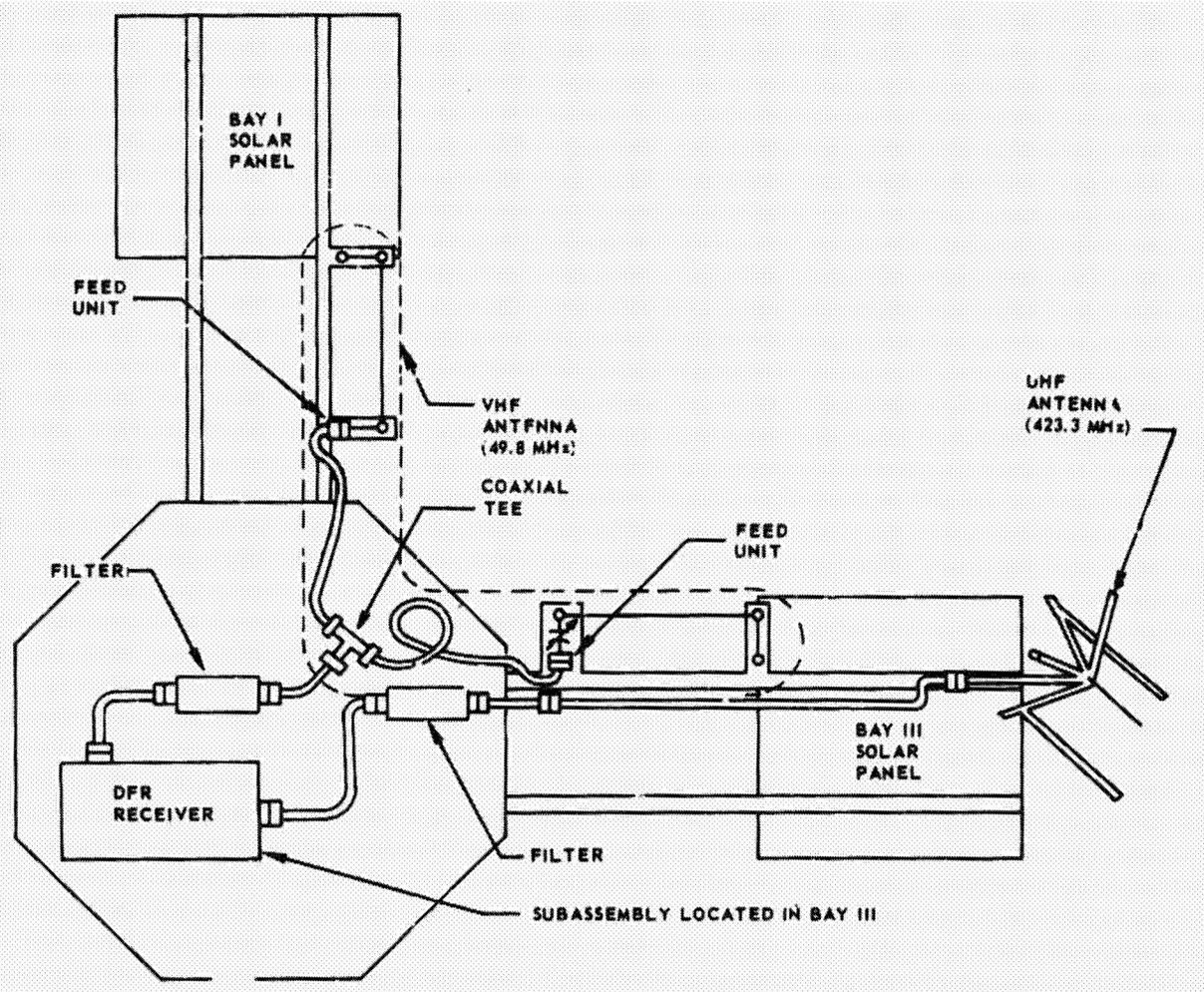


Fig. 39. Dual frequency receiver antennas subsystem

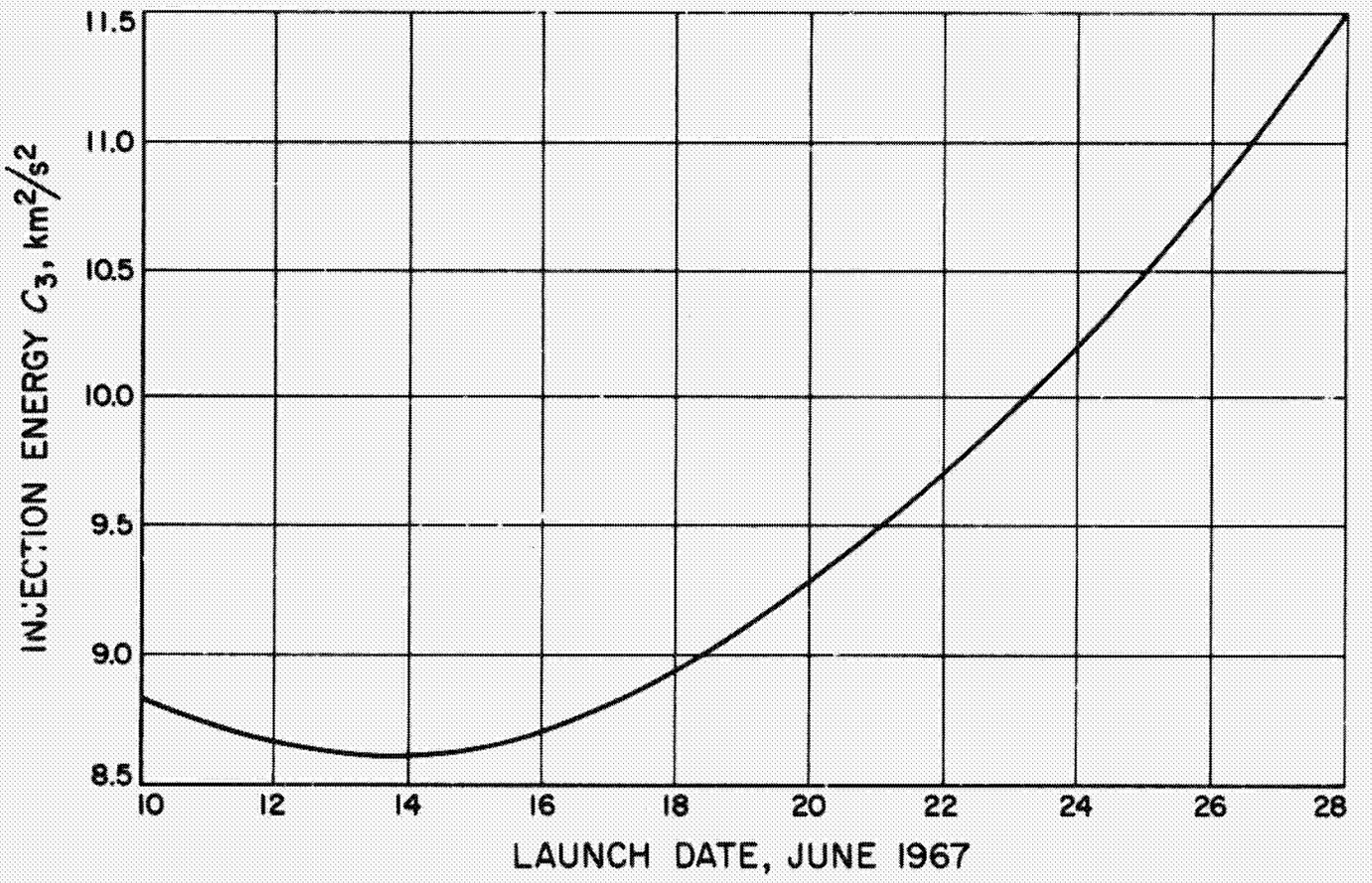


Fig. 40. Injection energy C_3 vs launch date

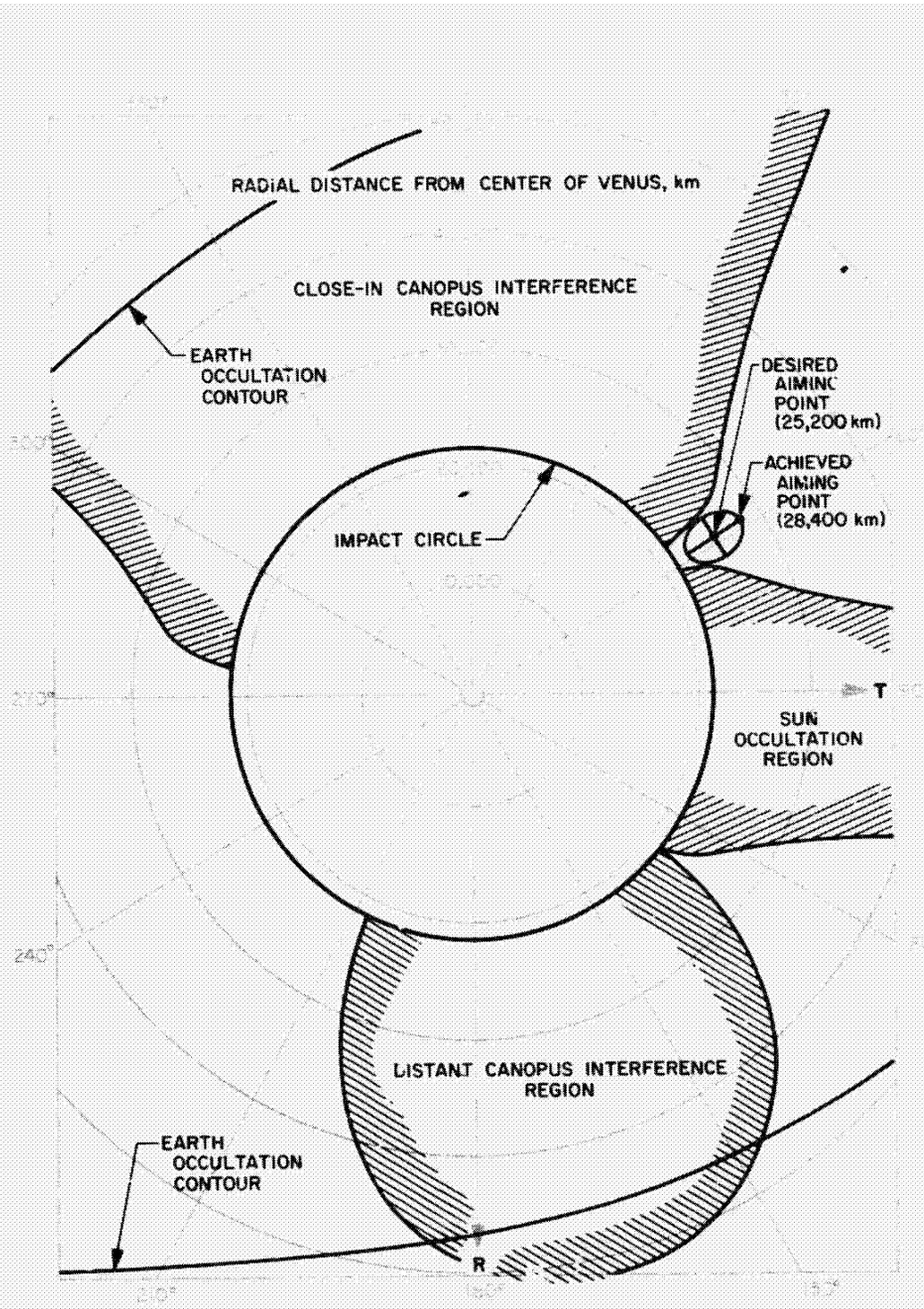


Fig. 41. Aiming zone and constraint regions for 14 June 1967, launch

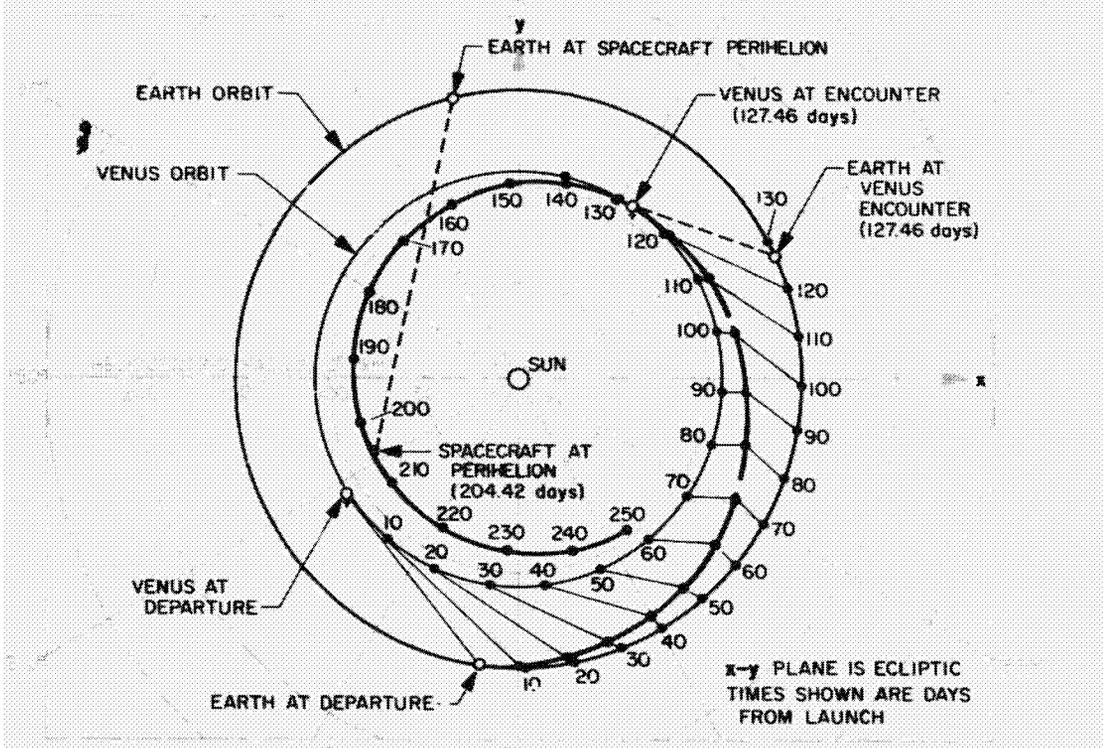


Fig. 42. Heliocentric trajectory on ecliptic plane for 14 June 1967, launch

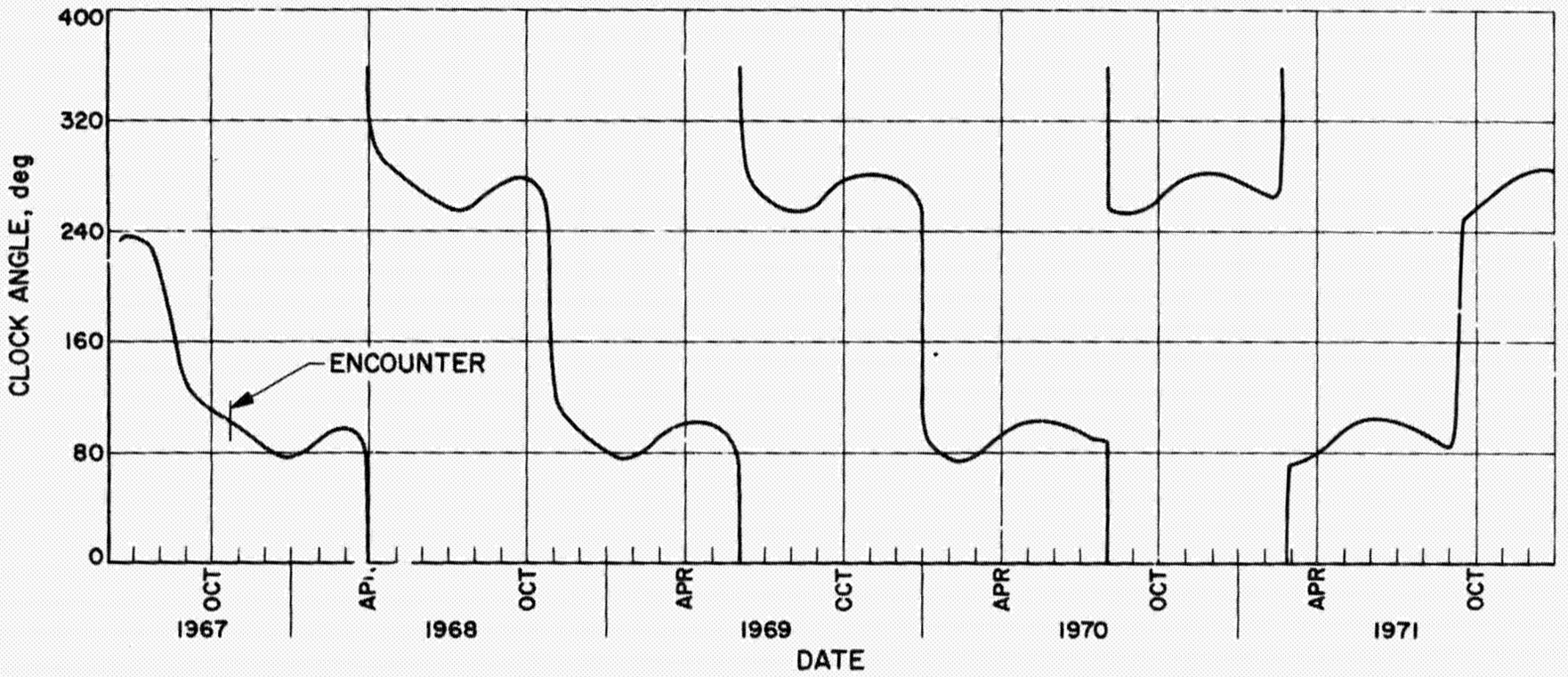


Fig. 43. Clock angle of earth, launch through 1971

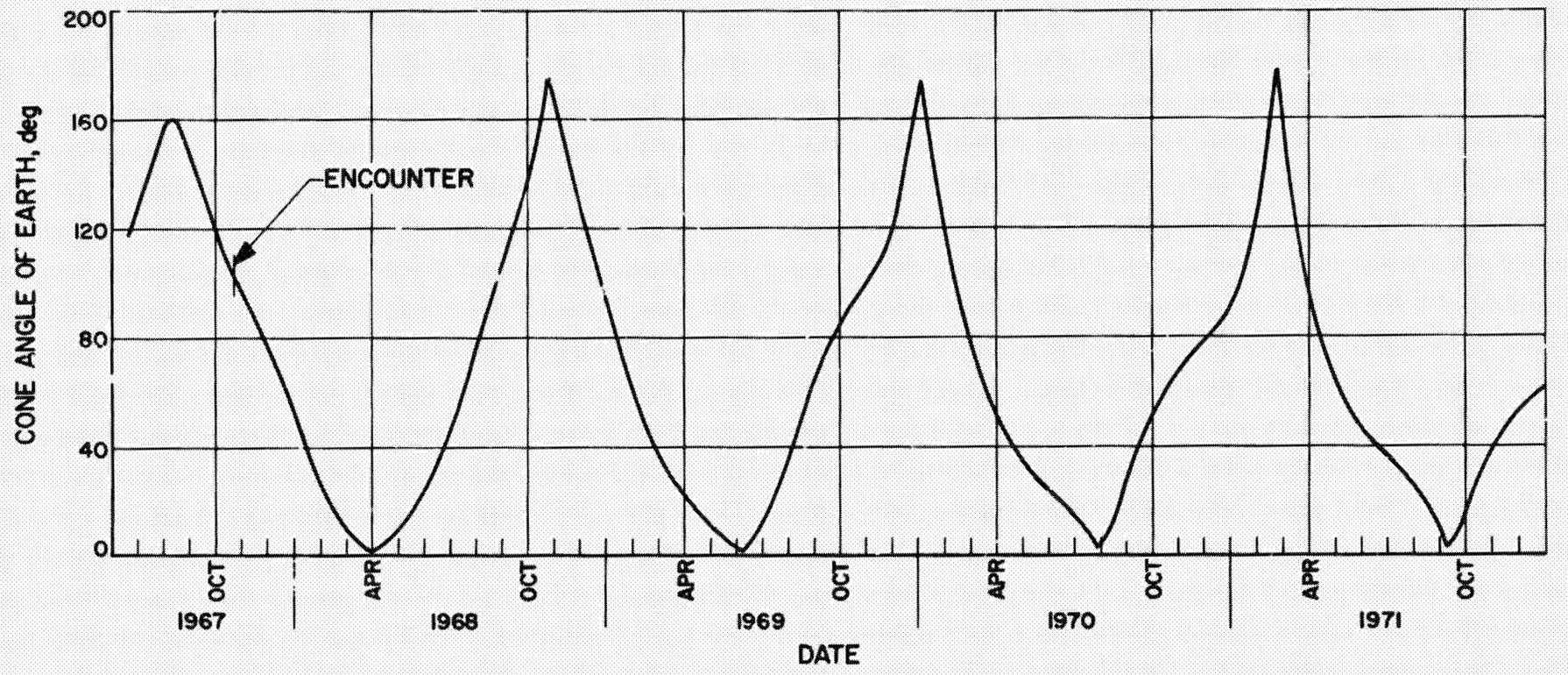


Fig. 44. Cone angle of earth, launch through 1971

Fig. 45. Cone angle of Canopus, launch through 1971

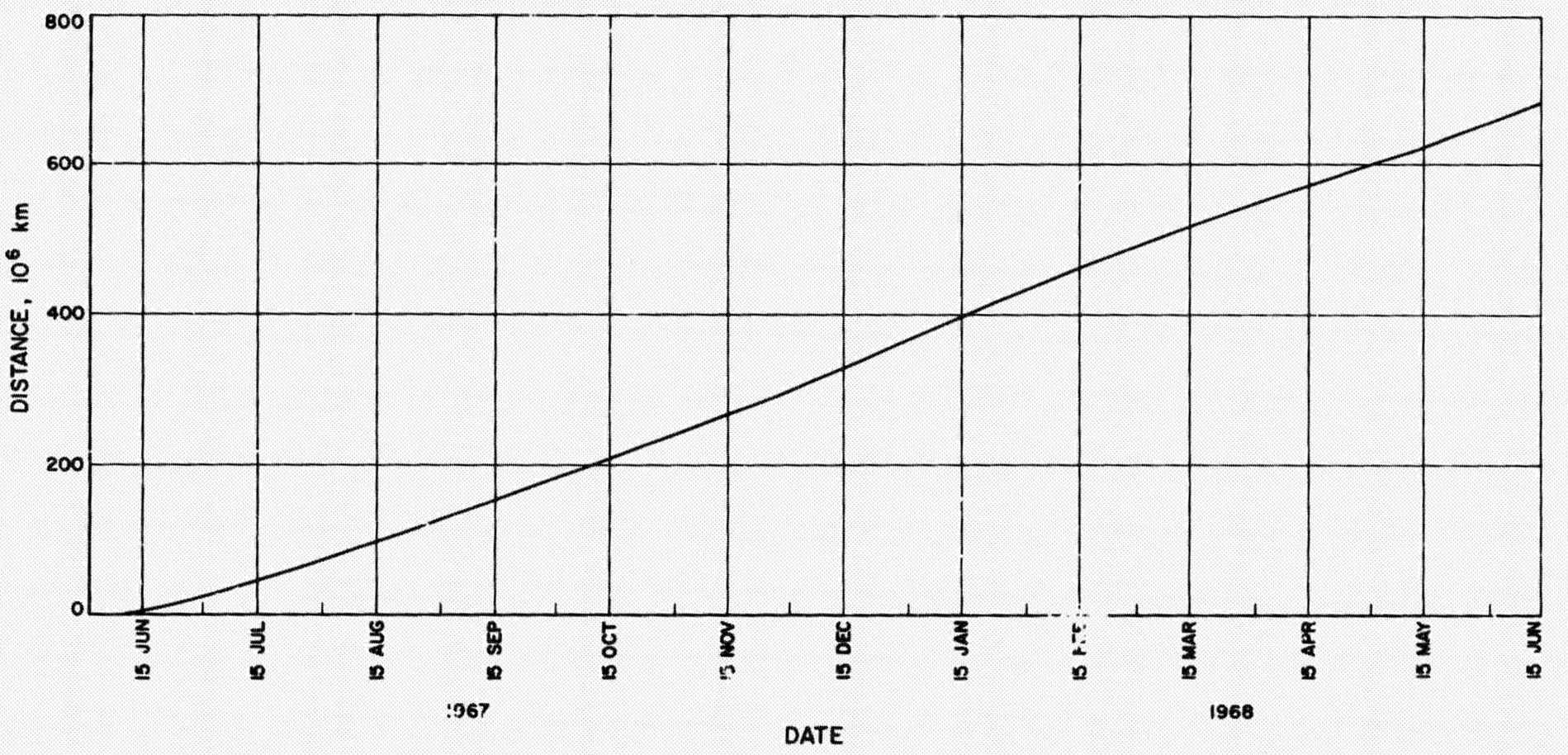


Fig. 46. Distance traveled along heliocentric arc, launch through 1971

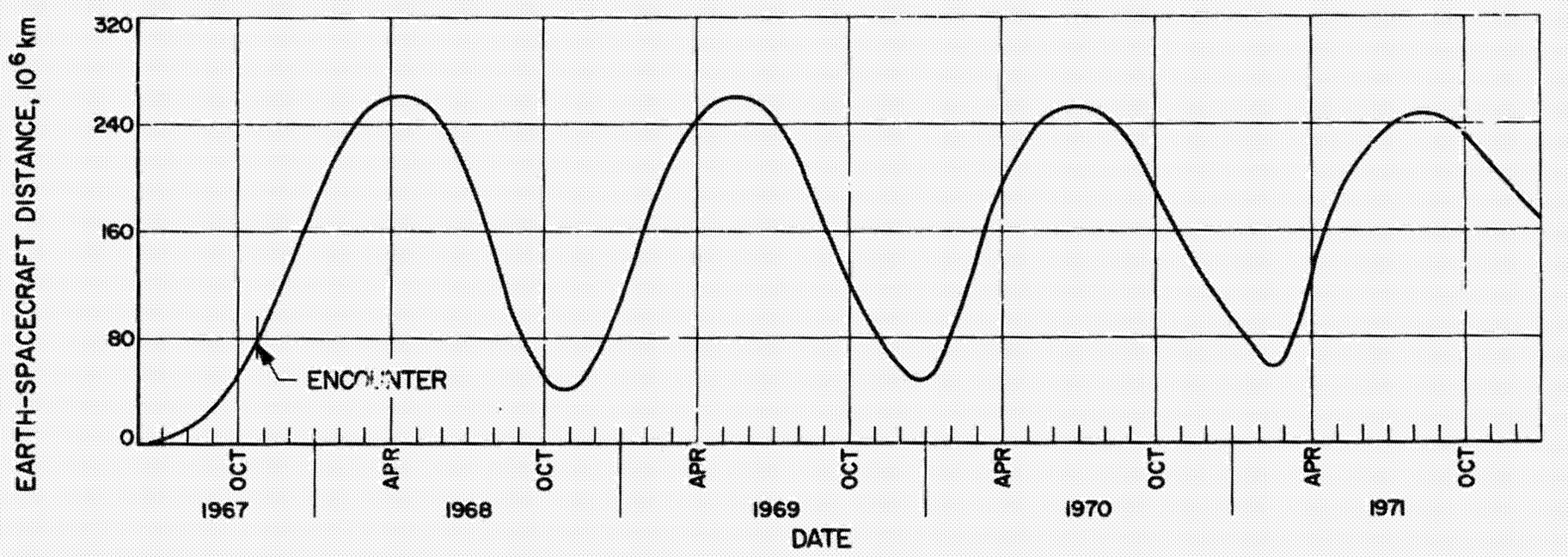


Fig. 47. Spacecraft distance from earth, launch through 1971

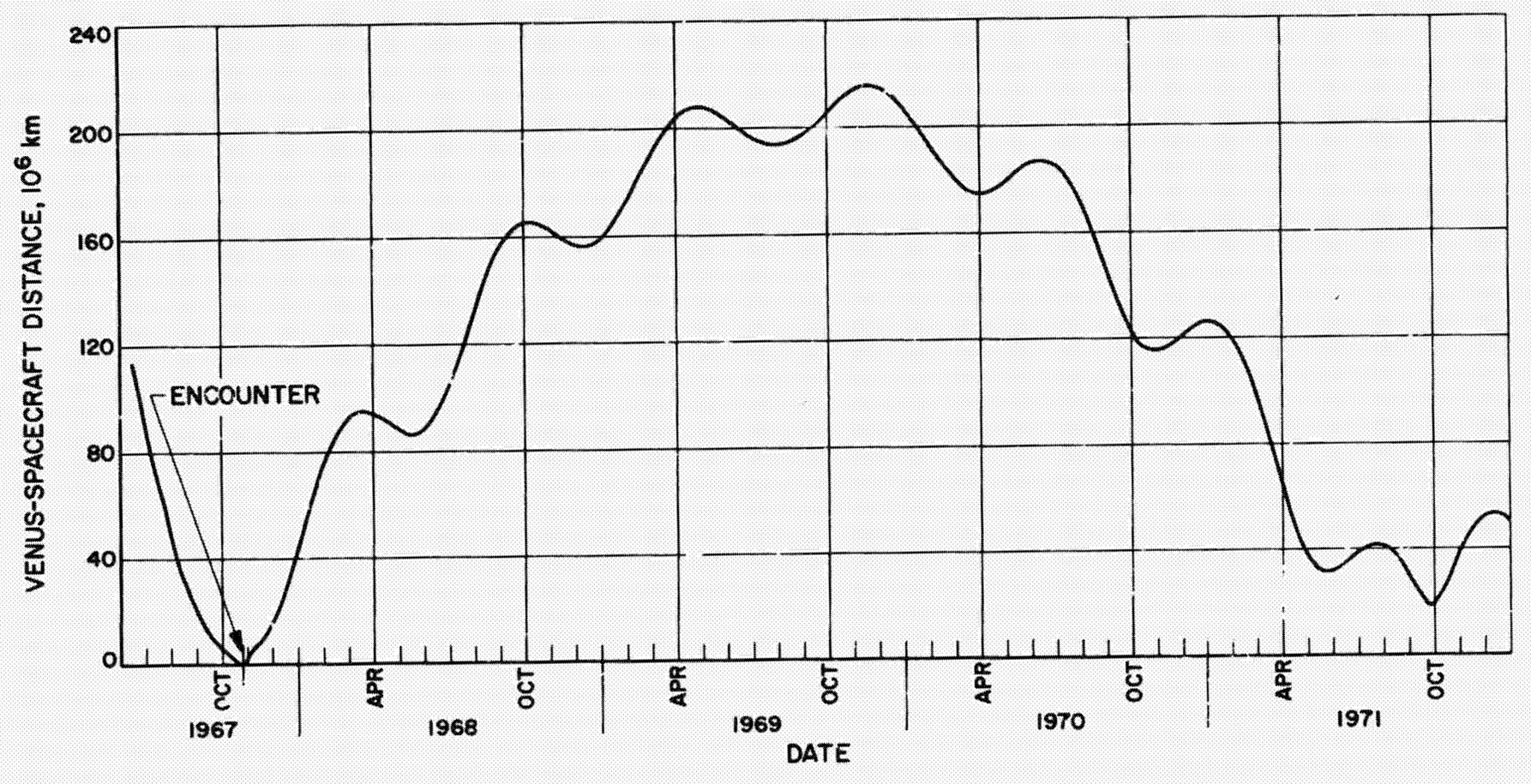


Fig. 48. Spacecraft distance from Venus, launch through 1971

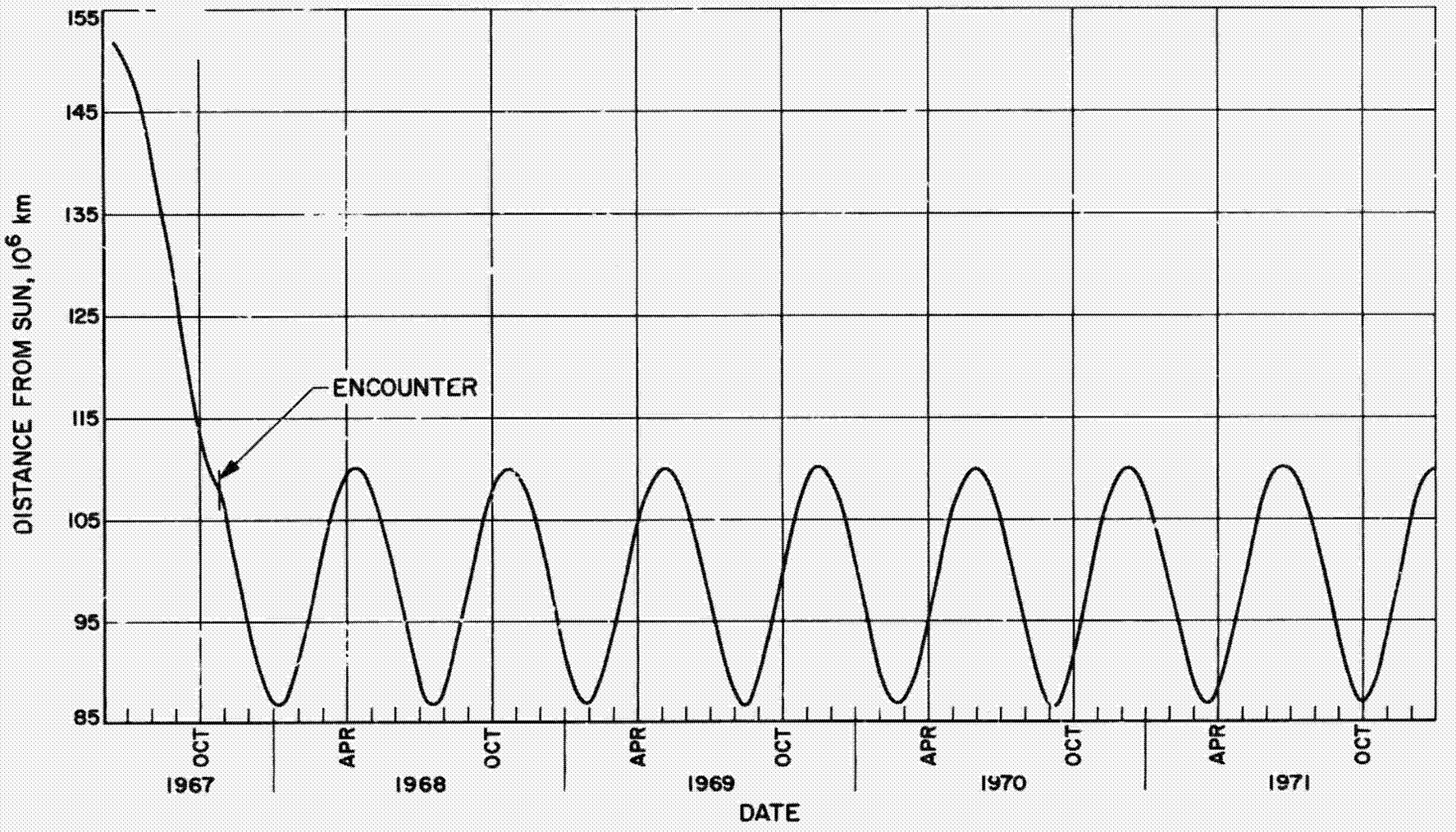


Fig. 49a. Spacecraft distance from sun, launch through 1971, linear graph

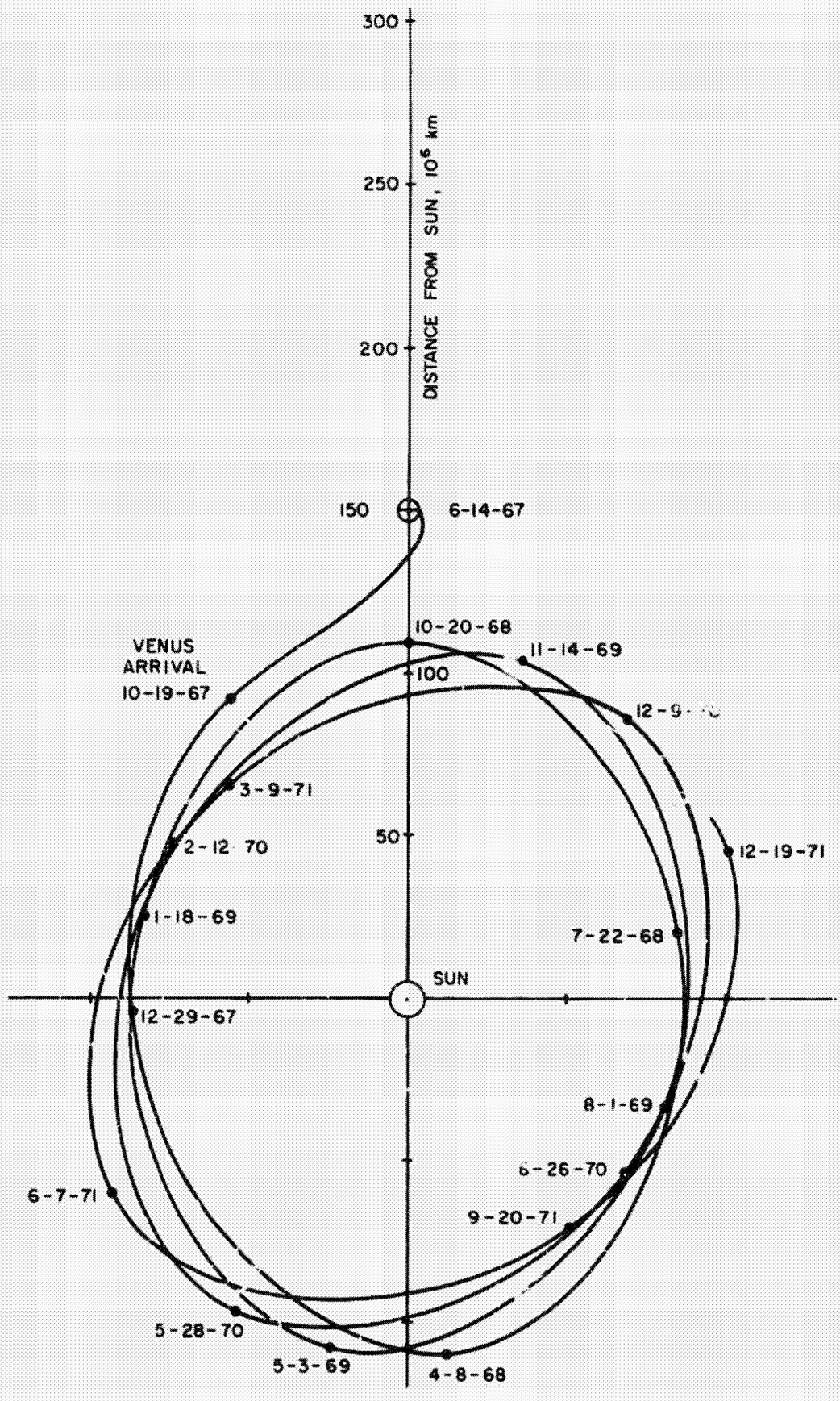


Fig. 49b. Spacecraft distance from sun, launch through 1971, rotating coordinate system with fixed sun–earth line

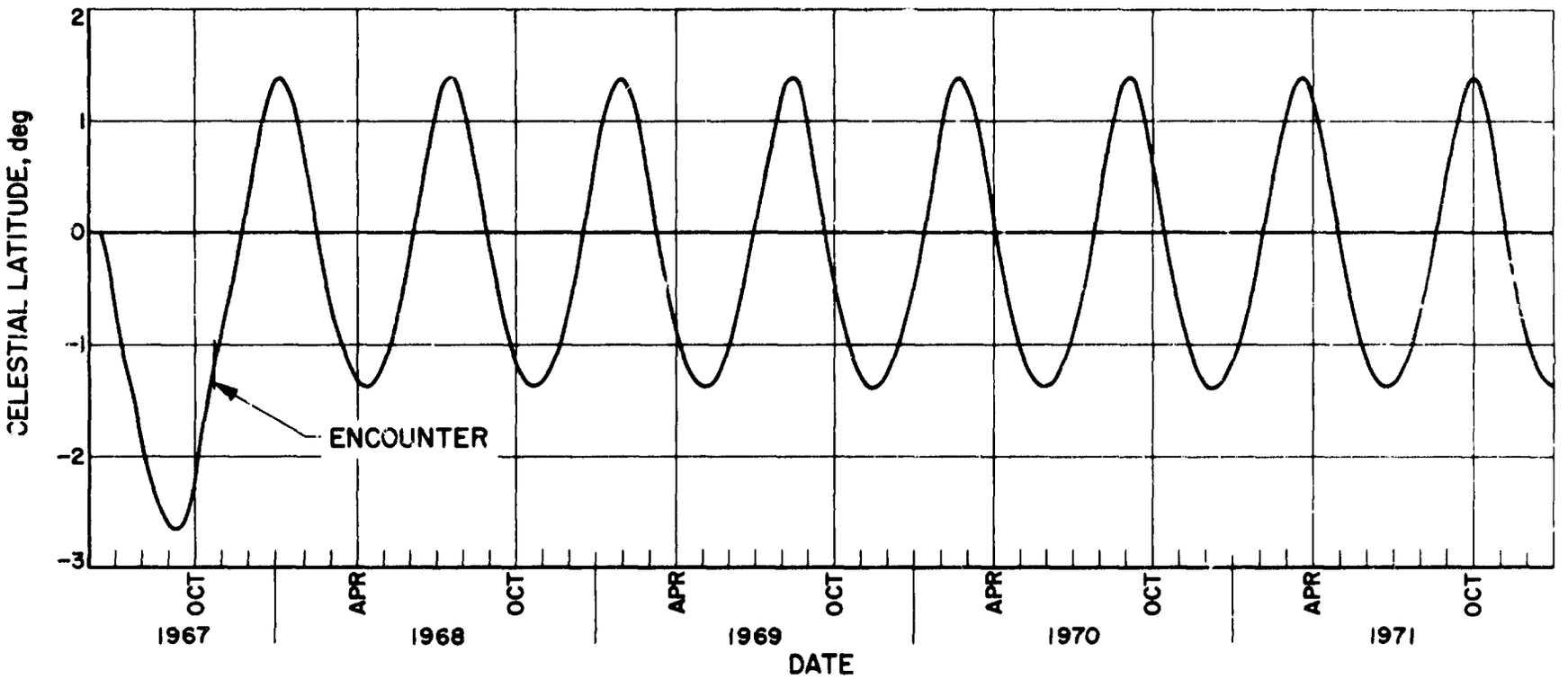


Fig. 50. Spacecraft celestial latitude, launch through 1971

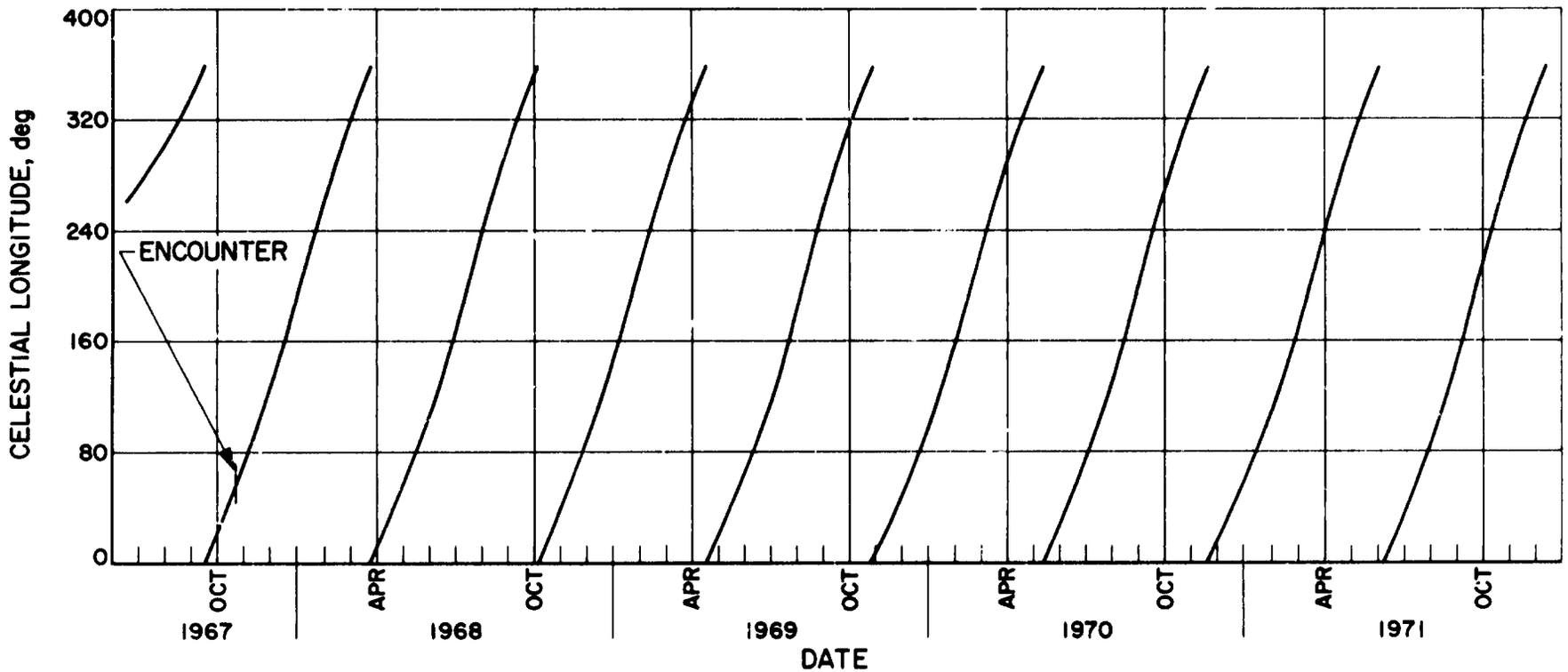


Fig. 51. Spacecraft celestial longitude, launch through 1971

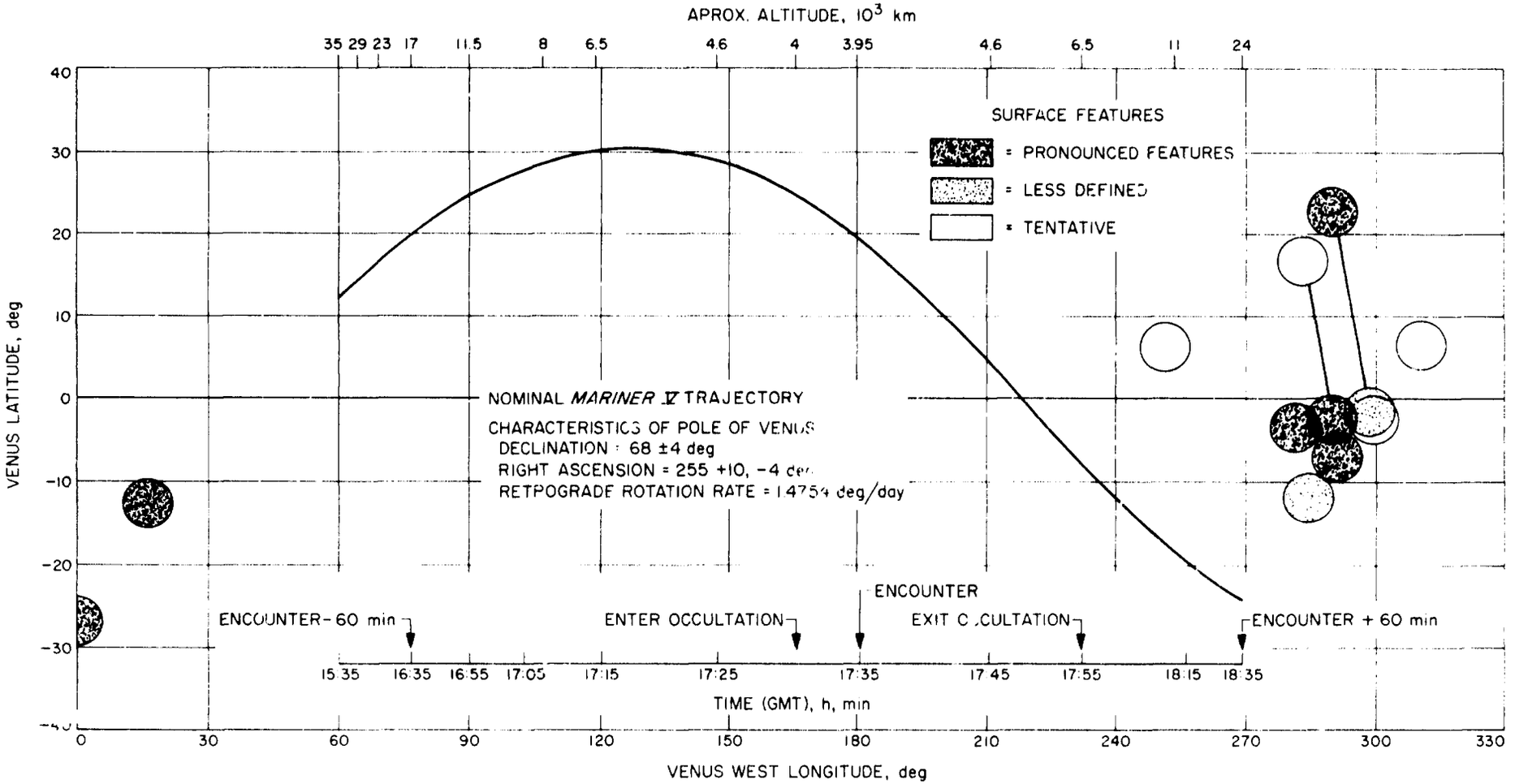


Fig. 52. Mariner V Venus track with respect to fixed radar features

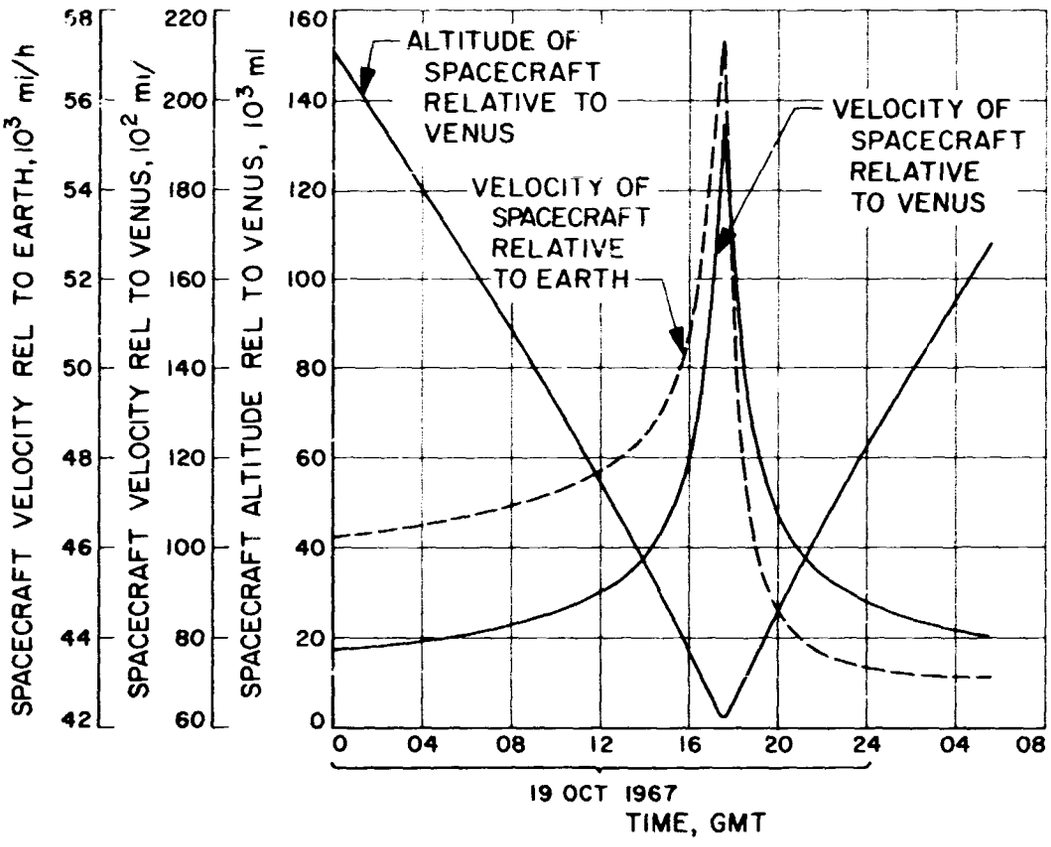
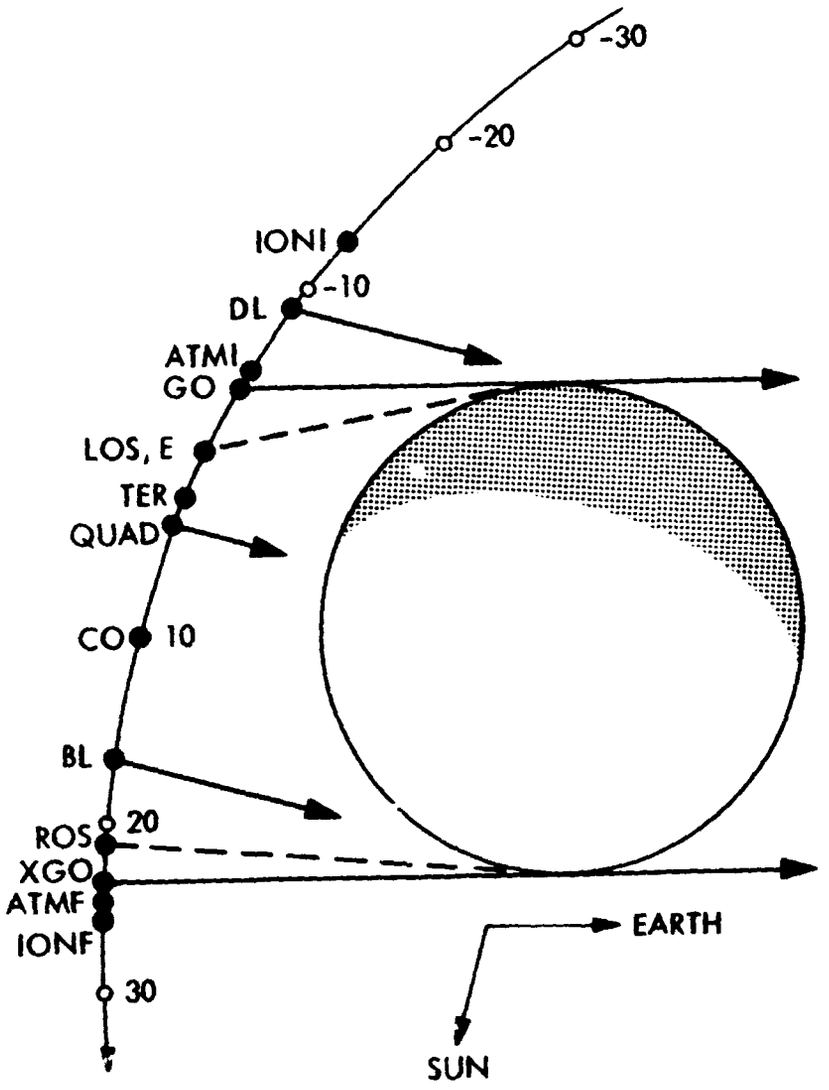


Fig. 53. Encounter velocities and altitude



ATMF = final observation of atmospheric effect on S-band signal

ATMI = initial observation of atmospheric effect on S-band signal

BL = bright limb of planet observed by ultraviolet photometer

CO = center of geometrical occultation

DL = dark limb of planet observed by ultraviolet photometer

E = periapsis

GO = Geometrical occultation; earth–spacecraft line of sight intersects dark limb of planet

IONF = final detection of ionosphere by dual frequency receiver

IONI = initial detection of ionosphere by dual frequency receiver

LOS = loss of spacecraft radio signal resulting from occultation

QUAD = quadrature; sun-Venus-Mariner V angle 90 deg

ROS = reacquisition of signal by Goldstone DSCC

TER = terminator crossing observed by ultraviolet photometer

XGO = exit from geometrical occultation at bright limb

Fig. 54. Time and position of key encounter events

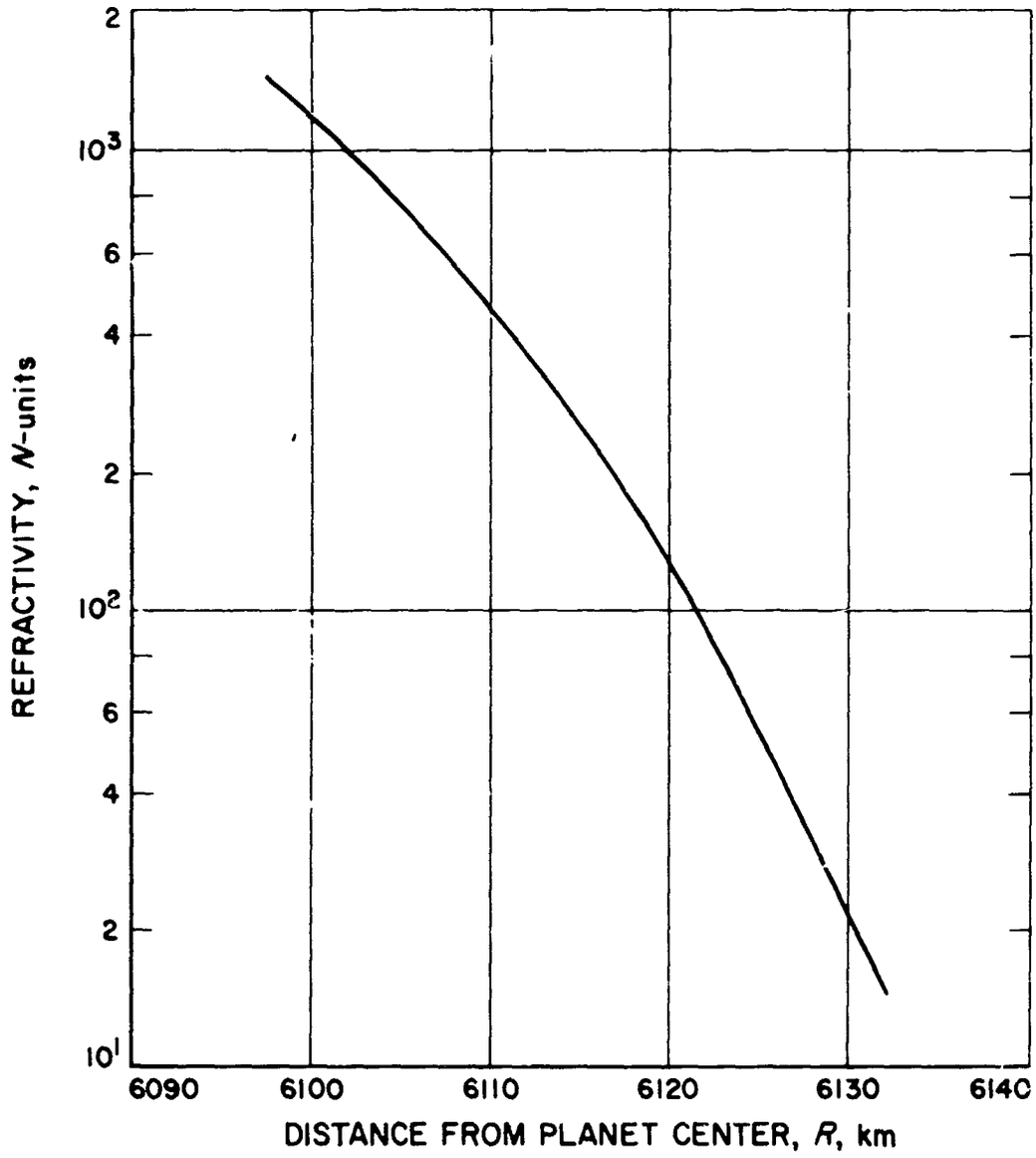


Fig. 55. Refractivity as a function of height in the Venus atmosphere

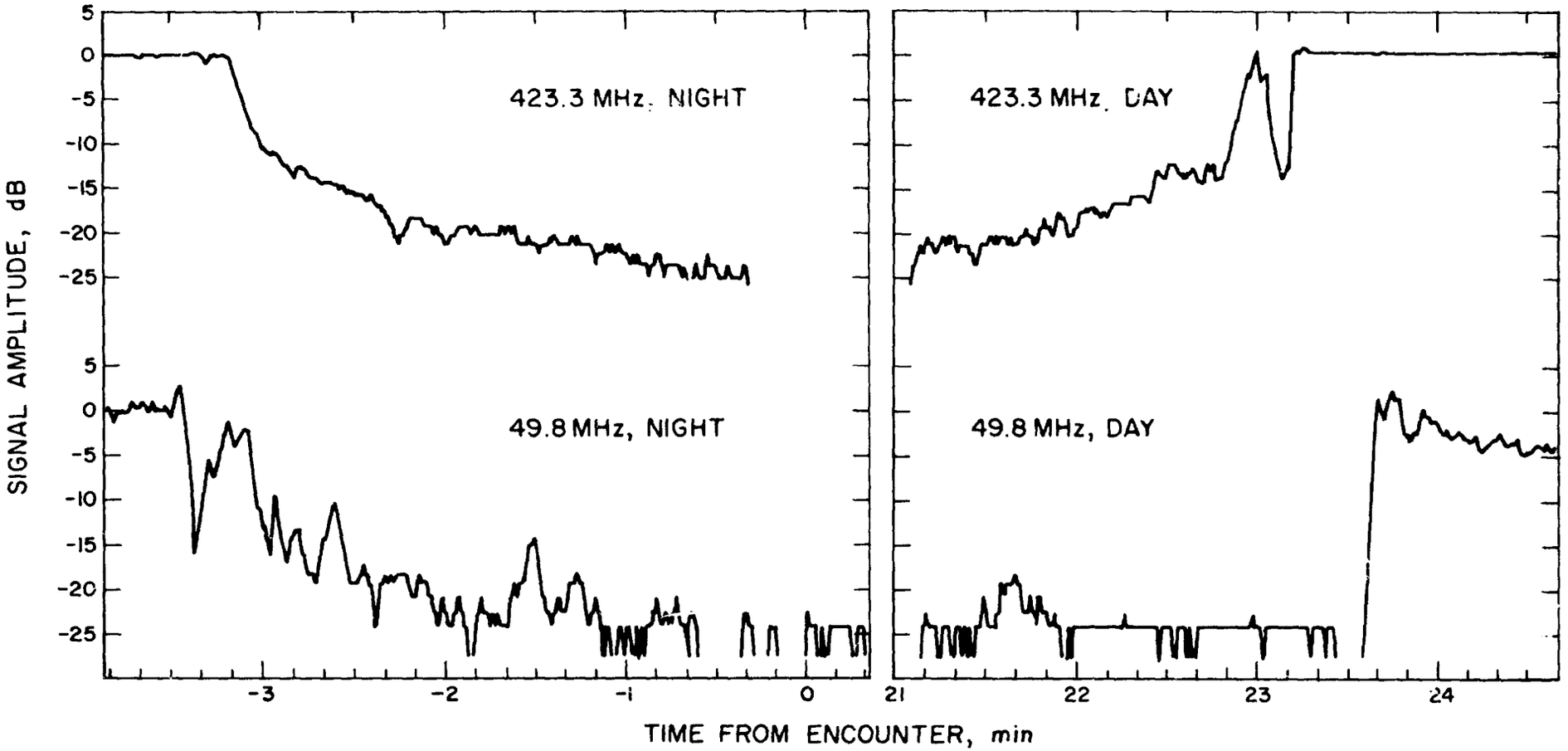


Fig. 56. Signal amplitudes at two frequencies during occultation

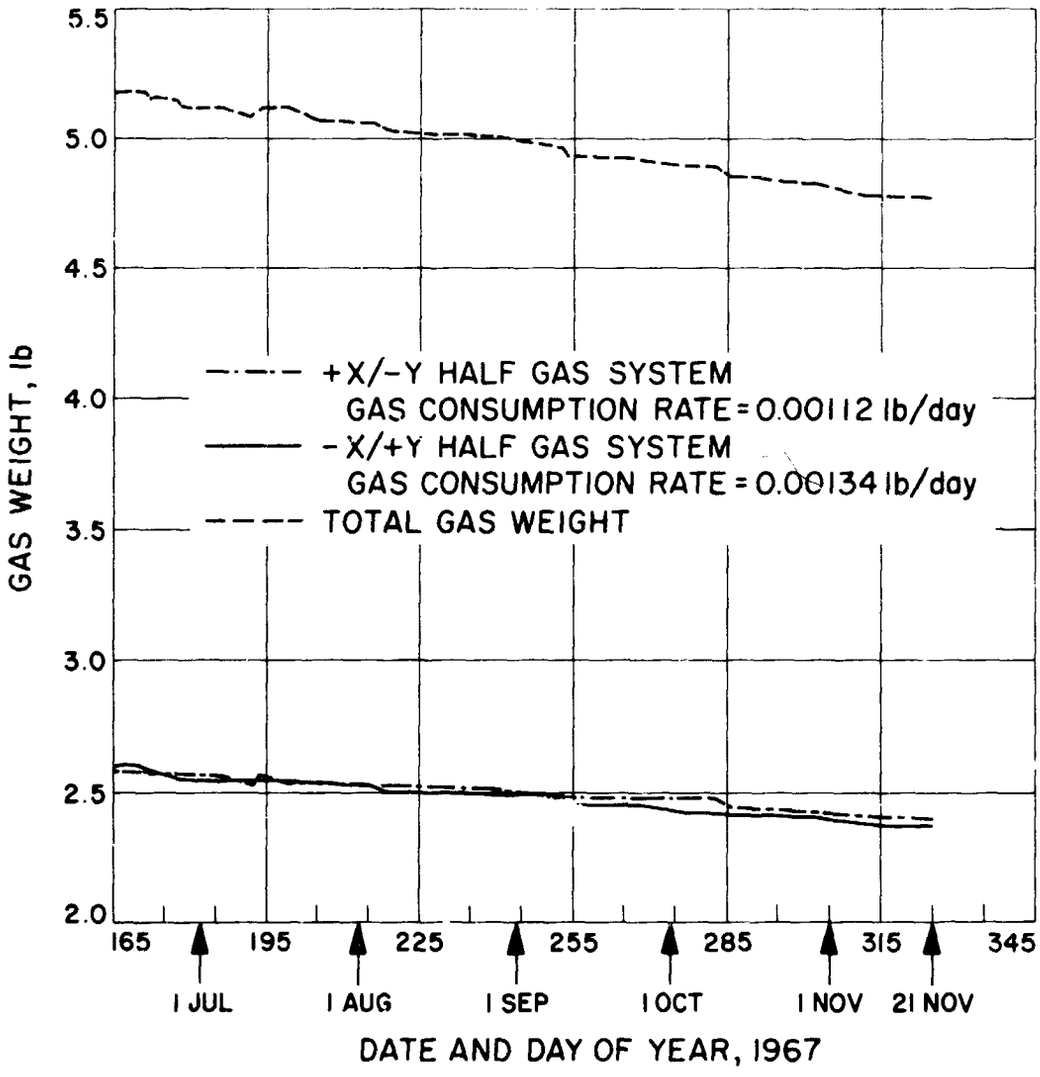


Fig. 57. Gas weight history